THE
POPULAR SCIENCE
MONTHLY.

JUNE, 1903.

HERTZIAN WAVE WIRELESS TELEGRAPHY. I.*

By Dr. J. A. FLEMING, F.R.S.,
PROFESSOR OF ELECTRICAL ENGINEERING, UNIVERSITY COLLEGE, LONDON.

THE immense public interest which has been aroused of late years in the subject of telegraphy without connecting wires has undoubtedly been stimulated by the achievements of Mr. Marconi in effecting communication over great distances by means of Hertzian waves. The periodicals and daily journals, which are the chief avenues through which information reaches the public, whilst eager to describe in a sensational manner these wonderful applications of electrical principles, have done little to convey an intelligible explanation of them. Hence it appeared probable that a service would be rendered by an endeavor to present an account of the present condition of electric wave telegraphy in a manner acceptable to those unversed in the advanced technicalities of the subject, but acquainted at least with the elements of electrical science. It is the purpose of these articles to attempt this task. We shall, however, limit the discussion to an account of the scientific principles underlying the operation of this particular form of wireless telegraphy, omitting, as far as possible, references to mere questions of priority and development.

The practical problem of electric wave wireless telegraphy, which has been variously called Hertzian wave telegraphy, Marconi teleg-

* This series of articles is based on the Cantor lectures delivered before the Society of Arts, London, in March, 1903. The lectures were attended by many of the leading British scientific men and electrical engineers, and attracted wide attention as the most complete and authoritative statement hitherto made of wireless telegraphy. In writing the articles for The Popular Science Monthly, the author has omitted advanced technicalities in order that the substance may be suitable for the general reader.—Editor.

raphy, or spark telegraphy (*Funkentelegraphie*), is that of the production of an effect called an electric wave or train of electric waves, which can be sent out from one place, controlled, detected at another place, and interpreted into an alphabetic code. Up to the present time, the chief part of that intercommunication has been effected by means of the Morse code, in which a group of long and short signs form the letter or symbol. Some attempts have been made with more or less success to work printing telegraphs and even writing or drawing telegraphs by Hertzian waves, but have not passed beyond the experimental stage, whilst wireless telephony by this means is still a dream of the future.

We shall, in the first place, consider the transmitting arrangements and, incidentally, the nature of the effect or wave transmitted; in the second place, the receiving appliances; and finally, discuss the problem of the isolation or secrecy of the intelligence conveyed between any two places.

The transmitter used in Hertzian wave telegraphy consists essentially of a device for producing electric waves of a type which will travel over the surface of the land or sea without speedy dissipation, and the important element in this arrangement is the *radiator,* by which these waves are sent out. It will be an advantage to begin by explaining the electrical action of the radiator, and then proceed to discuss the details of the transmitting appliances.

It will probably assist the reader to arrive most easily at a general idea of the functions of the various portions of the transmitting arrangements, and in particular of the radiator, if we take as our starting point an analogy which exists between electric wave generation for telegraphic purposes and air wave generation for sound signal purposes. Most persons have visited some of the large lighthouses which exist around our coasts and have there seen a steam or air *siren,* as used for the production of sound signals during fogs. If they have examined this appliance, they will know that it consists, in the first place, of a long metal tube, generally with a trumpet-shaped mouthpiece. At the bottom of this tube there is a fixed plate with holes in it, against which revolves another similarly perforated plate. These two plates separate a back chamber or wind chest from the tube, and the wind chest communicates with a reservoir of compressed air or a high-pressure steam boiler. In the communication pipe there is a valve which can be suddenly opened for a longer or shorter time. When the movable plate revolves, the coincidence or non-coincidence of the holes in the two plates opens or shuts the air passage way very rapidly. Hence when the blast of air or steam is turned on, the flow is cut up by the revolving plates into a series of puffs which inflict blows upon the stationary air in the siren tube. If these blows come at the rate,

say of a hundred a second, they give rise to aerial oscillations in the tube, which impress the ear as a deep, musical note or roar; and this continuous sound can be cut up by closing the valve intermittently into long and short periods, and so caused to signal a letter according to the Morse code, denoting the name of the lighthouse. In this case the object is to produce: first, aerial vibrations in the tube, giving rise to a train of powerful air waves; secondly, to intermit this wave-train so as to produce an intelligible signal; and thirdly, to transmit this wave as far as possible through space.

The production of a sound or air wave can only be achieved by administering a very sudden blow to the general mass of the air in the tube. This impulse must be sufficient to call into operation the inertia and elastic qualities of the air. It is found, moreover, that the amplitude of the resulting wave, or the loudness of the sound, is increased by suitably proportioning the length of the siren pipe and the frequency of the air puffs; whilst the distance at which it is heard depends also in some degree upon the form of the mouthpiece.

Inside the siren tube, when it is in operation, the air molecules are in rapid vibratory motion in the direction of the length of the tube. If we could at any one instant examine the distribution and changes of air pressure in the tube, we should find that at some places there are large, and at others small, variations in air pressure. These latter places are called the *nodes* of pressure. At the pressure nodes, however, we should find large variations in the velocity of the air particles, and these points are called the *antinodes* of velocity. In those places at which the pressure variation is greatest, the velocity changes are least, and *vice versa*. Outside the tube, as a result of these air motions in it, we have a hemispherical air wave produced, which travels out from the mouthpiece as a center; and if we could examine the distribution of air pressure and velocity through all external space, we should find a distribution which is periodic in space as well as time, constituting the familiar phenomenon of an air wave.

Turning then to consider the production of an electric, instead of an air wave, we notice in the first place that the medium with which we are concerned is the *ether* filling all space. This ether permits the production of physical changes in it which are analogous to, but not identical in nature with, the pressures and movements which constitute a sound wave. The Hertzian radiator is an appliance for acting on the ether as the siren acts on the air. It produces a wave in it, and it can be shown that all the parts of the above described siren apparatus have their electrical equivalents in the transmitter employed in Hertzian wave wireless telegraphy.

To understand the nature of an electric wave we must consider, in the first place, some properties of the ether. In this medium we can

at any place produce a state called *electric displacement* or *ether strain,* as we can produce compression or rarefaction in air; and, just as the latter changes are said to be created by mechanical force, so the former is said to be due to *electric force.* We can not define more clearly the nature of this ether strain or displacement until we know much more about the structure of the ether than we do at present. We can picture to ourselves the operation of compressing air as an approximation of the air molecules, but the difficulty of comprehending the nature of an electric wave arises from the fact that we can not yet definitely resolve the notion of electric strain into any simpler or more familiar ideas.

We have to be content, therefore, to disguise our present ignorance by the use of some descriptive term, such as *electric strain, electrostatic strain* or *ether strain,* to describe the directed condition of the space around a body in a state of electrification which is produced by electric force. This electric strain is certainly not of the nature of a compression in the ether, but much more akin to a twist or rotational strain in a solid body.

For our present purpose it is not so necessary to postulate any particular theory of the ether as it is to possess some consistent hypothesis, in terms of which we can describe the phenomena which will concern us. These effects are, as we shall see, partly states of electrification on the surface or distributions of electric current in wires or rods, and partly conditions in the space outside them, which we are led to recognize as distributions of electric strain and of an associated effect called *magnetic flux.*

We find such a theory at hand at the present time in the electronic theory of electricity, which has now been sufficiently developed and popularized to make it useful as a descriptive hypothesis.* This theory has the great recommendation that it offers a means of abolishing the perplexing dualism of ether and ponderable matter, and gives a definite and, in a sense, objective meaning to the word electricity. In this physical speculation, the chief subject of contemplation is the electron, or ultimate particle of negative electricity, which, when associated in greater or less number with a matrix of some description, forms the atom of ponderable matter. To avoid further hypothesis, this matrix may be called the *co-electron;* and we shall adopt the view that a single chemical atom is a union of a *co-electron* with a surrounding envelope or group of electrons, one or more of the latter being detachable. We need not stop to speculate on the structure of the atomic core or co-electron, whether it is composed of positive and negative electrons or

* For a more detailed account of this hypothesis, the reader is referred to an article by the present writer entitled: 'The Electronic Theory of Electricity,' published in the POPULAR SCIENCE MONTHLY for May, 1902.

of something entirely different. The single electron is the indivisible unit or atomic element of so-called negative electricity, and the neutral chemical atom deprived of one electron is the unit of positive electricity. On this hypothesis, the chemical atom is to be regarded as a microcosm, a sort of a solar system in miniature, the component electrons being capable of vibration relatively to the atomic center of mass. Furthermore, from this point of view it is the electron which is the effective cause of radiation. It alone has a grip on the ether whereby it is able to establish wave motion in the latter.

Dr. Larmor has developed in considerable detail an hypothesis of the nature of an electron which makes it the center or convergence-point of lines of a self-locked ether strain of a torsional type. The notion of an atom merely as a 'center of force' was one familiar to Faraday and much supported by Boscovich and others. The fatal objection to the validity of this notion as originally stated was that it offers no possibility of explaining the inertia of matter. On the electronic hypothesis, the source of all inertia is the inertia of the ether, and until we are able to dissect this last quality into anything simpler than the time-element involved in the production of an ether strain or displacement, we must accept it as an ultimate fact, not more elucidated because we speak of it as the inductance of the electron.

We postulate, therefore, the following ideas: We have to think of the ether as a homogeneous medium in which a strain of some kind, most probably of a rotational type, is possible. This strain appears only under the influence of an appropriate stress called the electric force, and disappears when the force is removed. Hence to create this strain necessitates the expenditure of energy. An electron is a center or convergence-point of lines of permanent ether strain of such nature that it can not release itself. To obtain some idea of the nature of such a structure, let us imagine a flat steel band formed into a ring by welding the ends together. There is then no torsional strain. If, however, we suppose the band cut in one place, one end then given half a turn and the cut ends again welded, we shall have on the band a self-locked twist, which can be displaced on the band, but which can not release itself or be released except by cutting the ring. Hence we see that to make an electron in an ether possessing torsional elasticity would require creative energy, and when made, the electron can not destroy itself except by occupying simultaneously the same place as an electron of opposite type. Every electron extends, therefore, as Faraday said of the atom, throughout the universe, and the properties that we find in the electron are only there because they are first in the universal medium, the ether. Every line of ether or electric strain

must, therefore, be a self-closed line, or else it must terminate on an electron and a co-electron.

So far we have only considered the electron at rest. If, however, it moves, it can be mathematically demonstrated that it must give rise to a second form of ether strain which is related to the electric strain as a twist is related to a thrust or a vortex ring to a squirt in liquid or a rotation to a linear progression. The ether strain which results from the lateral movement of lines of electric strain is called the *magnetic flux,* and it can be mathematically shown that the movement of an electron, consisting when at rest of a radial convergence of lines of electric strain, must be accompanied by the production of self-closed lines of magnetic flux, distributed in concentric circles or rings round it, the planes of these circles being perpendicular to the direction of motion of the electron.

This electronic hypothesis, therefore, affords a basis on which we can build up a theory affording an explanation of the nature of the intimate connection known to exist between ether, matter and electricity. The electron is the connecting link between them all, for it is in itself a center of convergent ether strain; isolated, it presents itself as electricity of the negative or resinous kind; and, in combination with co-electrons and other electrons, it forms the atoms of ponderable matter. At rest the electron or the co-electron constitutes an electric charge, and when in motion it is an electric current. A steady flux or drift of electrons in one direction and co-electrons in the opposite direction is a continuous electric current, whilst their mere oscillation about a mean position is an alternating current. Furthermore, the vibration of an electron, if sufficiently rapid, enables it to establish what are called electric waves in the ether, but which are really detached and self-closed lines of ether strain distributed in a periodic manner through space.

We have, therefore, to start with, three conceptions concerning the electron, viz: Its condition when at rest; its state when in uniform motion; and its operations when in vibration or rapid oscillation. In the first case, by our fundamental supposition, it consists of lines of ether strain of a type called the electric strain, radiating uniformly in all directions. When in uniform motion, it can be shown that these lines of electric strain tend to group themselves in a plane perpendicular to the line of motion drawn through the electron, and their lateral motion generates another class of strain called the magnetic strain, disposed in concentric circles described round the electron and lying in this equatorial plane.

The proof of the above propositions can not be given verbally, but requires the aid of mathematical analysis of an advanced kind. The

reader must be referred for the complete demonstration to the writings of Professor J. J. Thomson* and Mr. Oliver Heaviside.†

In the third case, when the electron vibrates, we have a state in which self-closed lines of electric strain and magnetic flux are thrown off and move away through the ether, constituting electric radiation. The manner in which this happens was first described by Hertz in a paper on 'Electric Oscillations treated according to the Method of Maxwell.'‡ As this phenomenon lies at the very root of Hertzian wave wireless telegraphy, we must spend a moment or two in its careful examination.

Let us imagine two metal rods placed in line and constituting what is called a linear oscillator. Let these rods have adjacent ends separated by a very small air space, and let one rod be charged with positive and the other with negative electricity. On the electronic theory this is explained by stating that there is an accumulation of electrons in one and of co-electrons in the other. These charges create a distribution of electric strain throughout their neighborhood, which follows approximately the same law of distribution as the lines of magnetic force of a bar magnet, and may be roughly represented as in Fig. 1. Suppose then that the air gap is destroyed, these charges move towards each other and disappear by uniting, the lines of electric strain then collapse, and as they shrink in give rise to circular lines of magnetic flux embracing the rods. This external distribution of magnetism constitutes an electric current in the rods produced by the movement of the two opposite electric charges. At this stage it may be explained that the electrons or atoms of electricity can in some cases make their way freely between the atoms of ponderable matter. The former are incomparably smaller than the latter, and in those cases in which this electronic movement can take place easily, we call the material a good conductor.

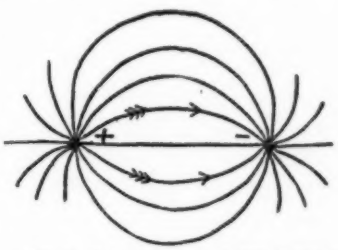


FIG. 1. LINES OF ELECTRIC STRAIN BETWEEN A POSITIVE AND NEGATIVE ELECTRON AT REST.

Suppose then the electric charges reappear in reversed positions and go through an oscillatory motion. The result in the external space would be the alternate production of lines of electric strain and magnetic flux, the direction of these lines being reversed each half cycle.

* See J. J. Thomson, 'Recent Researches in Electricity and Magnetism,' Chapter I., 16.

† See O. Heaviside, 'Electromagnetic Theory,' Vol. I., p. 54.

‡ Wiedemann's *Annalen*, 36, p. 1, 1889. Or in his republished papers, 'Electric Waves,' p. 137. English translation by D. E. Jones.

Inside the rods we have a movement of electrons and co-electrons to and fro, electric charges at the ends of the rods alternating with electric currents in the rods, the charges being at a maximum when the current is zero, and the current at a maximum when the charges have for the moment disappeared. Outside the rods we have a corresponding set of charges, lines of electric strain stretching from end to end of the rod, alternating with rings of magnetic flux embracing the rod. So far we have supposed the oscillation to be relatively a slow one.

Imagine next that the to and fro movement of the electrons or charges is sufficiently rapid to bring into play the inertia quality of the medium. We then have a different state of affairs. The lines of strain in the external medium can not contract or collapse quickly

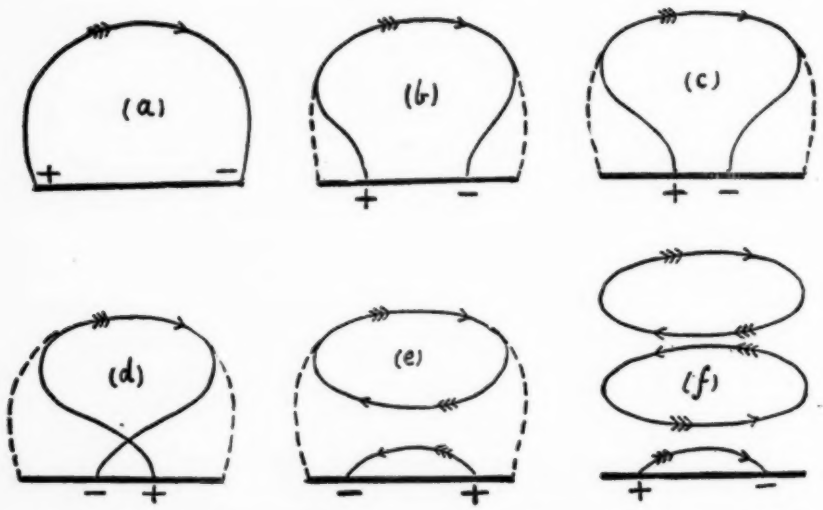


FIG. 2. SUCCESSIVE STAGES IN THE DEFORMATION OF A LINE OF STRAIN BETWEEN POSITIVE AND NEGATIVE ELECTRONS IN RAPID OSCILLATION, SHOWING CLOSED LOOP OF ELECTRIC STRAIN THROWN OFF.

enough to keep up with the course of events, or movements of the electrons in the rods, and hence their regular contraction and absorption is changed into a process of a different kind. As the electrons and co-electrons, *i. e.*, the electric charges, vibrate to and fro, the lines of electric strain connecting them are nipped in and thrown off as completely independent and closed lines of electric strain, and at each successive alternation, groups or batches of these loops of strain are detached from the rod, and, so to speak, take on an independent existence. The whole process of the formation of these self-closed lines of electric strain is best understood by examining a series of diagrams which roughly represent the various stages of the process. In Fig. 2 we have a diagram (*a*) the curved line in which delineates approxi-

mately the form of one line of electric strain round a linear oscillator, with spark gap in the center, one half being charged positively and the other negatively. Let us then suppose that the insulation of the spark gap is destroyed, so that the opposite electric charges rush together and oscillate to and fro. The strain lines at each oscillation are then crossed or decussate, and the result, as shown in Fig. 2, *d*, is that a portion of the energy of the field is thrown off in the form of self-closed lines of strain (see Fig. 2, *e*). At each oscillation of the charges the direction of the lines of strain springing from end to end of the radiator is reversed. It is a general property of lines of strain, whether electric or magnetic, that there is a tension along the line and a pressure at right angles. In other words, these lines of electric strain are like elastic threads, they tend to contract in the direction of their length and press sideways on each other when in the same direction. Hence it is not difficult to see that as each batch of self-closed lines of strain is thrown off, the direction of the strain round each loop is alternately in one direction and in the other. Hence these loops of electric strain press each other out, and each one that is formed squeezes the already formed loops further and further from the radiator. The loops, therefore, march away into space (see Fig. 2, *f*). If we imagine ourselves standing at a little distance at a point on the equatorial line and able to see these loops of strain as they pass, we should recognize a procession of loops, consisting of alternately directed strain lines marching past. This movement through the ether of self-closed lines of electric strain constitutes what is called electric radiation.

Hence along a line drawn perpendicular to the radiator through its center, there is a distribution of electric strain normal to that line, which is periodic in space and in time. Moreover, in addition to these lines of electric strain, there are at right angles to them another set of self-closed lines of magnetic flux. Alternated between the instants when the electric charges at the ends of the radiator are at their maximum, we have instants when the radiator rod is the seat of an electric current, and hence the field round it is filled with circular lines of magnetic flux coaxial with the radiator. As the current alternates in direction each half period, these rings of magnetic flux alternate in direction as regards the flux, and hence we must complete our mental picture of the space round the radiator rods when the charges are oscillating by supposing it filled with concentric rings of magnetic flux which are periodically reversed in direction, and have their maximum values at those instants and places where the lines of electric strain have their zero values. Accordingly, along the equatorial line we have two sets of strains in the ether, distributed periodically in space and in time. First, the lines of electric strain

in the plane of the radiator, and secondly, the lines of magnetic flux at right angles to these. At any one point in space these two changes, the strain and the flux, succeed each other periodically, being, however, at right angles in direction. At any one moment these two effects are distributed periodically or cyclically through space, and these changes in time and space constitute an *electric wave* or electromagnetic wave.

We may then summarize the above statements by saying that the most recent hypothesis as to the nature of electrical action and of electricity itself is briefly comprised in the following statements: The universally diffused medium called the ether has had created in it certain centers of strain or radiating points from which proceed lines of strain, and these centers of force are called electrons. Electrons must, therefore, be of two kinds, positive and negative, according to the direction of the strain radiating from the center. These electrons in their free condition constitute what we call electricity, and the electrons themselves are the atoms of electricity which, in one sense, is, therefore, as much material as that which we call ordinary gross or ponderable matter.

Collocations of these electrons constitute the atoms of gross matter, and we must consider that the individuality of any atom is not determined merely by the identity of the electrons composing it, but by the permanence of their arrangement or form. In any mass of material substance there is probably a continual exchange of electrons from one atom to another, and hence at any one given moment, whilst a number of the electrons are an association forming material atoms, there will be a further number of isolated but intermingled electrons, which are called the free electrons. In substances which we call good conductors, we must imagine that the free electrons have the power of moving freely through or between the material atoms, and this movement of the electrons constitutes a current of electricity; whilst a superfluity of electrons of either type in any one mass of matter constitutes what we call a charge of electricity. Hence an electrical oscillation, which is merely a very rapid alternating current taking place in a conductor, is on this hypothesis assumed to consist in a rapid movement to and fro of the free electrons. We may picture to ourselves, therefore, a rod of metal in which electrical oscillations are taking place, as similar to an organ pipe or siren tube in which movements of the air particles are taking place to and fro, the free electrons corresponding with the air particles.

Owing to the nature of the structure of an electron, it follows, however, that every movement of an electron is accompanied by changes in the distribution of the electric strain or ether strain taking place throughout all surrounding space, and, as already explained, certain very rapid movements of the electrons have the effect of detaching

closed lines of strain in the ether which move off through space, forming, when cyclically distributed, an electric wave.

We may next proceed to apply these principles to the explanation of the action of the simplest form of Hertzian wave telegraphic radiator, viz., the Marconi aerial wire. In its original form this consists of a long vertical insulated wire *A*, the lower end of which is attached to one of the spark balls *S* of an induction coil *I*, the other spark ball being connected to earth *E*, and the two spark balls being placed a few millimeters apart (see Fig. 3). When the coil is set in action, oscillatory or Hertzian sparks pass between the balls, electric oscillations are set up in the wire and electric waves are radiated from it. Deferring for the moment a more detailed examination of the operations of the coil and at the spark gap, we may here say that the action which takes place in the aerial wire is as follows: The wire is first charged to a high potential, let us suppose, with negative electricity. We may imagine this process to consist in forcing additional electrons into it, the induction coil acting as an electron pump. Up to a certain pressure the spark gap is a perfect insulator, but at a critical pressure, which for spark gap lengths of four or five millimeters and balls about one centimeter in diameter approximates to three thousand volts per millimeter, the insulation of the air gives way, and the charge in the wire rushes into the earth. In consequence, however, of the inertia of the medium or of the electrons, the charge, so to speak, overshoots the mark, and the wire is then left with a charge of opposite sign. This again in turn rebounds, and so the wire is discharged by a series of electrical oscillations, consisting of alternations of static charge and electric discharge. We may fasten our attention either on the events taking place in the vertical wire or in the medium outside, but the two sets of phenomena are inseparably connected and go on together. When the aerial wire is statically charged, we may describe it by saying that there is an accumulation of electrons or co-electrons in it. Outside the wire there is, however, a distribution of electric strain, the strain lines proceeding from the wire to the earth (see Fig. 4).

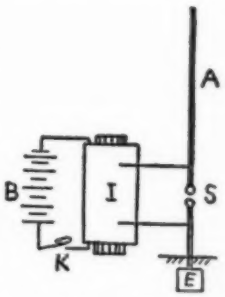


FIG. 3. SIMPLE MARCONI RADIATOR. *B*, battery; *I*, induction coil; *K*, signalling key; *S*, spark gap; *A*, aerial wire; *E*, earth plate.

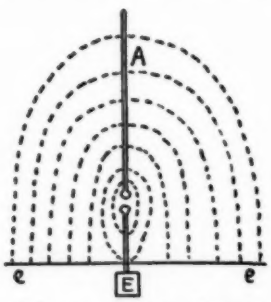


FIG. 4. LINES OF ELECTRIC STRAIN (DOTTED LINES) EXTENDING BETWEEN A MARCONI AERIAL *A* AND THE EARTH *ee* BEFORE DISCHARGE.

The wire has *capacity* with respect to the earth, and it acts like the inner coating of a Leyden jar, of which the dielectric is the air and ether around it, and the outer coating is the earth's surface. When the discharge takes place, we may consider that electrons rush out of the wire and then rush back again into it. At the moment when the electrons rush out of or into the aerial wire, we say there is an electric current flowing into or out of the wire, and this electron movement, therefore, creates the magnetic flux which is distributed in concentric circles round the wire. This current, and, therefore, motion of electrons, can be proved to exist by its heating effect upon a fine wire inserted in series with the aerial, and in the case of large aerials it may have a mean value of many amperes and a maximum value of hundreds of amperes. Inside the aerial wire we have, therefore, alternations of electric potential or charge and electric current, or we may call it electron-pressure and electron-movement.

There is, therefore, an oscillation of electrons in the aerial wire, just as in the case of an organ pipe there is an oscillation of air molecules in the pipe. Outside the aerial we have variations and distributions of electric strain and magnetic flux. The resemblance between the closed organ-pipe and the simple Marconi aerial is, in fact, very complete. In the case of the closed organ-pipe, we have a longitudinal oscillation of air molecules in the pipe. At the open end or mouthpiece, where we have air moving in and out, the air movement is alternating and considerable, but there is little or no variation of air pressure. At the upper or closed end of the pipe we have great variation of air pressure, but little or no air movement (see Fig. 5).

FIG. 5. AMPLITUDE OF PRESSURE VARIATION IN A CLOSED ORGAN PIPE, INDICATED BY THE ORDINATES OF THE DOTTED LINE *xy*.

Compare this now with the electrical phenomena of the aerial. At the spark ball or lower end we have little or no variation of potential or electron pressure, but we have electrons rushing into and out of the aerial at each half oscillation, forming the electric discharge or current. At the upper or insulated end we have little or no current, but great variations of potential or electron pressure. Supposing we could examine the wire inch by inch, all the way up from the spark balls at the bottom to the top, we should find at each stage of our journey that the range of variation and maximum value of the current in the wire became less and those of the potential became greater. At the bottom we have nearly zero potential or no electric pressure, but large current, and at the top end, no current, but great variation of potential.

We can represent the amplitude of the current and potential values

along the aerial by the ordinates of a dotted line so drawn that its distance from the aerial represents the potential oscillation or current oscillation at that point (see Fig. 6).

This distribution of potential and current along the wire does not necessarily imply that any one electron moves far from its normal position. The actual movement of any particular air molecule in the case of a sound wave is probably very small, and reckoned in millionths of an inch. So also we must suppose that any one electron may have a small individual amplitude of movement, but the displacement is transferred from one to another. Conduction in a solid may be effected by the movement of free electrons intermingled with the chemical atoms, but any one electron may be continually passing from a condition of freedom to one of combination.

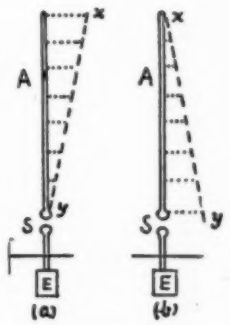


FIG. 6. (*a*) DISTRIBUTION OF ELECTRIC PRESSURE IN A MARCONI AERIAL *A*, (*b*) DISTRIBUTION OF ELECTRIC CURRENT IN A MARCONI AERIAL, AS SHOWN BY THE ORDINATES OF THE DOTTED LINE *zy*.

So much for the events inside the wire, but now outside the wire its electric charge is represented by lines of electric strain springing from the aerial to the earth. It must be remembered that every line of strain terminates on an electron or a co-electron. Hence when the discharge or spark takes place between the spark balls, the rapid movement of the electrons in the wire is accompanied by a redistribution and movement of the lines of strain outside. As the negative charge flows out of the aerial the ends of the strain lines abutting on to it run down the wire and are transferred to the earth, and at the next instant this semi-loop of electric or ether strain, with its ends on the earth, is pushed out sideways from the wire by the growth of a new set of lines of ether strain in an opposite direction. The process is best understood by consulting a series of diagrams which represent the distribution and approximate form of a few of the strain lines at successive instants (see Fig. 7). In between the lines of formation of the successive strain lines between the aerial and the earth, corresponding to the successive alternate electric charges of the aerial with opposite sign, there are a set of concentric rings of magnetic flux formed round it which are alternately in opposite directions, and these expand out, keeping step with the progress of the detached strain loops and having their planes at right angles to the latter. As the semi-loops of electric strain march outwards with their feet on the ground, these strain lines must always be supposed to terminate on electrons, but not continually on the same electrons. Since the earth is a conductor, we must suppose that there is a continual migration of the electrons forming the

atoms of the earth, and that when one electron enters an atom, another leaves it. Hence corresponding to the electric wave in the space above, there are electrical changes in the ground beneath. This view is confirmed by the well-known fact that the achievement of Hertzian wave telegraphy is much dependent on the nature of the surface over which it is conducted, and can be carried on more easily over good conducting material, like sea water, than over badly conducting dry land.

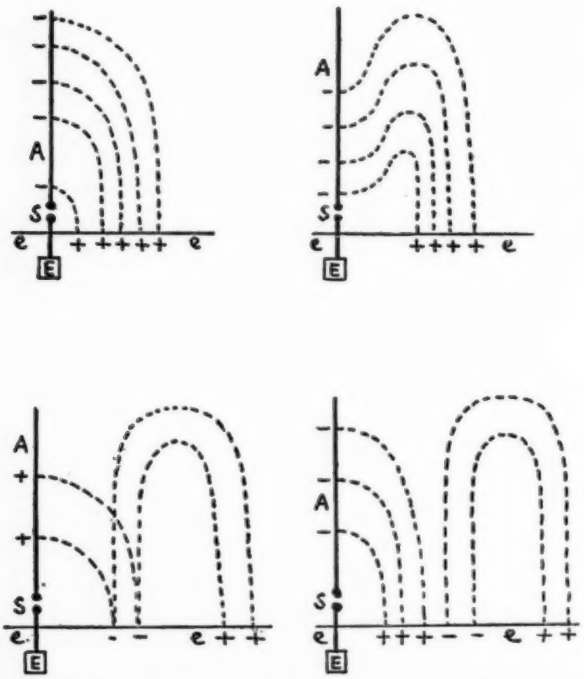


FIG. 7. SUCCESSIVE STAGES IN THE PRODUCTION OF A SEMI-LOOP OF ELECTRIC STRAIN BY A MARCONI AERIAL RADIATOR.

The matter may be viewed, however, from another standpoint. Good conductors are opaque to Hertzian waves; in other words, are non-absorptive. The energy of the electric wave is not so rapidly absorbed when it glides over a sea surface as when it is passing over a surface which is an indifferent conductor, like dry land. In fact, it is possible by the improvement of the signals to detect a heavy fall of rain in the space between two stations separated only by dry land. It is, however, clear that on the electronic theory the progression of the lines of electric strain can only take place if the surface over which they move is a fairly good conductor, unless these lines of strain form completely closed loops. Hence we may sum up by saying that there are three sets of phenomena to which we must pay attention in formu-

lating any complete theory of the aerial. The first is the operation taking place in the vertical wire, which is described by saying that electrical oscillations or vibratory movements of electrons are taking place in it, and, on our adopted theory, it may be said to consist in a longitudinal vibration of electrons of such a nature that we may appropriately call the aerial an ether organ pipe. Then in the next place, we have the distribution and movement of the lines of electric strain and magnetic flux in the space outside the wire, constituting the electric wave; and lastly, there are the electrical changes in the conductor over which the wave travels, which is the earth or water surrounding the aerial. In subsequently dealing with the details of transmitting arrangements, attention will be directed to the necessity for what telegraphists call 'a good earth' in connection with Hertzian wave telegraphy. This only means that there must be a perfectly free egress and ingress for the electrons leaving or entering the aerial, so that nothing hinders their access to the conducting surface over which the wave travels. There must be nothing to stop or throttle the rush of electrons into or out of the aerial wire, or else the lines of strain can not be detached and travel away.

We may next consider more particularly the energy which is available for radiation and which is radiated. In the original form of simple Marconi aerial, the aerial itself when insulated forms one coating or surface of a condenser, the dielectric being the air and ether around it, and the other conductor being the earth. The electric energy stored up in it just before discharge takes place is numerically equal to the product of the capacity of the aerial and half the square of the potential to which it is charged.

If we call C the capacity of the aerial in microfarads, and V the potential in volts to which it is raised before discharge, then the energy storage in joules E is given by the equation,

$$E = \frac{CV^2}{2.10^6}$$

Since one joule is nearly equal to three quarters of a foot-pound, the energy storage in foot-pounds F is roughly given by the rule $F = \frac{3}{8}\ CV^2/10^6$. For spark lengths of the order of five to fifteen millimeters, the disruptive voltage in air of ordinary pressure is at the rate of 3,000 volts per millimeter. Hence if S stands for the spark length in millimeters, and C for the aerial capacity in microfarads, it is easy to see that the energy storage in foot-pound is

$$F = \frac{27CS^2}{8}$$

If the aerial consists of a stranded wire formed of 7/22 and has a length of 150 feet, and is insulated and held vertically with its lower end near the earth, it would have a capacity of about one three ten-thousandths of a microfarad or 0.0003 mfd.* Hence if it is used as a Marconi aerial and operated with a spark gap of one centimeter in length, the energy stored up in the wire before each discharge would be only one tenth (0.1) of a foot-pound.

By no means can all of this energy be radiated as Hertzian waves; part of it is dissipated as heat and light in the spark, and yet such an aerial can, with a sensitive receiver such as that devised by Mr. Marconi, make itself felt for a hundred miles over sea in every direction. This fact gives us an idea of the extremely small energy which, when properly imparted to the ether, can effect wireless telegraphy over immense distances. Of course, the minimum telegraphic signal, say the Morse dot, may involve a good many, perhaps half a dozen, discharges of the wire, but even then the amount of energy concerned in affecting the receiver at the distant place is exceedingly small.

The problem, therefore, of long distance telegraphy by Hertzian waves is largely, though not entirely, a matter of associating sufficient energy with the aerial wire or radiator. There are obviously two things which may be done; first, we may increase the capacity of the aerial, and secondly, we may increase the charging voltage or, in other words, lengthen the spark gap. There is, however, a well-defined limit to this last achievement. If we lengthen the spark gap too much, its resistance becomes too great and the spark ceases to be oscillatory. We can make a discharge, but we obtain no radiation. When using an induction coil, about a centimeter or at most a centimeter and a half is the limiting length of oscillatory sparks; in other words, our available potential difference is restricted to 30,000 or 40,000 volts. By other appliances we can, however, obtain oscillatory sparks having a voltage of 100,000 or 200,000 volts, and so obtain what Hertz called 'active sparks' five or six centimeters in length.

Turning then to the question of capacity, we may enquire in the next place how the capacity of an aerial wire can be increased. This has generally been done by putting up two or more aerial wires in contiguity and joining them together, and so making arrangements called in the admitted slang of the subject 'multiple aerials.' The measurement of the capacity of insulated wires can be easily carried out by means of an appliance devised by the author and Mr. W. C. Clinton, consisting of a rotating commutator which alternately charges the insulated wire at a source of known electromotive force and then

* The fraction 7/22 here denotes a stranded wire formed of seven strands, each single wire having a diameter expressed by the number 22 on the British standard wire gauge.

discharges it through a galvanometer. If this galvanometer is subsequently standardized, so that the ampere value of its deflection is known, we can determine easily the capacity C of the aerial or insulated conductor, reckoned in microfarads, when it is charged to a potential of V volts, and discharged n times a second through a galvanometer. The series of discharges are equivalent to a current, of which the value in amperes A is given by the equation,

$$A = \frac{nVC}{10^6}$$

and hence if the value of the current resulting is known, we have the capacity of the aerial or conductor expressed in microfarads, given by the formula,

$$C = \frac{A10^6}{nV}$$

A series of experiments made on this plan have revealed the fact that if a number of vertical insulated wires are hung up in the air and rather near together, the electrical capacity of the whole of the wires in parallel is not nearly equal to the sum of their individual capacities. If a number of parallel insulated wires are separated by a distance equal to about 3 per cent. of their length, the capacity of the whole lot together varies roughly as the square root of their number. Thus, if we call the capacity of one vertical wire in free space, unity, then the capacity of four wires placed rather near together will only be about twice that of one wire, and that of twenty-five wires will only be about five times one wire.

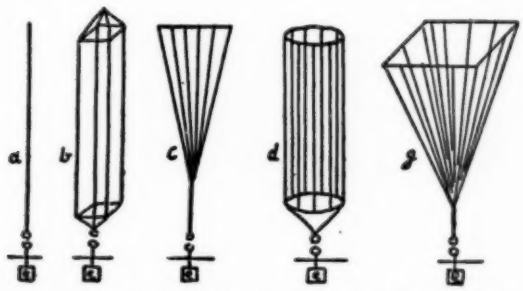


FIG. 8. VARIOUS FORMS OF AERIAL RADIATOR. *a*, Single Wire; *b*, Multiple Wire; *c*, Fan Shape; *d* Cylindrical; *g*, Conical.

This approximate rule has been confirmed by experiments made with long wires one hundred or two hundred feet in length in the open air. Hence it points to the fact that the ordinary plan of endeavoring to obtain a large capacity by putting several wires in parallel and not very far apart is very uneconomical in material. The diagrams in Fig. 8 show the various methods which have been employed

by Mr. Marconi and others in the construction of such multiple wire aerials. If, for instance, we put four insulated stranded 7/22 wires, each 100 feet long, about six feet apart, all being held in a vertical position, the capacity of the four together is not much more than twice that of a single wire. In the same manner, if we arrange 150 similar wires, each 100 feet long, in the form of a conical aerial, the wires being distributed at the top round a circle 100 feet in diameter, the whole group will not have much more than twelve times the capacity of one single wire, although it weighs 150 times as much.

The author has designed an aerial in which the wires, all of equal length, are arranged sufficiently far apart not to reduce each other's capacity.

As a rough guide in practice, it may be borne in mind that a wire about one tenth of an inch in diameter and one hundred feet long, held vertical and insulated, with its bottom end about six feet from the ground, has a capacity of 0.0002 of a microfarad, if no other earthed vertical conductors are very near it. The moral of all this is that the amount of electric energy which can be stored up in a simple Marconi aerial is very limited, and is not much more than one tenth of a joule or one fourteenth of a foot-pound, per hundred feet of 7/22 wire. The astonishing thing is that with so little storage of energy it should be possible to transmit intelligence to a distance of a hundred miles without connecting wires.

One consequence, however, of the small amount of energy which can be accumulated in a simple Marconi aerial is that this energy is almost entirely radiated in one oscillation or wave. Hence, strictly speaking, a simple aerial of this type does not create a train of waves in the ether, but probably at most a single impulse or two.

We shall later on consider some consequences which follow from this fact. Meanwhile, it may be explained that there are methods by which not only a much larger amount of energy can be accumulated in connection with an aerial, but more sustained oscillations created than by the original Marconi method. One of these methods originated with Professor Braun, of Strasburg, and a modification was first described by Mr. Marconi in a lecture before the Society of Arts of London.* In this method the charge in the aerial is not created by the direct application to it of the secondary electromotive force of an induction coil, but by means of an induced electromotive force created in the aerial by an oscillation transformer. The method due to Professor Braun is as follows: A condenser or Leyden jar has one terminal, say its inside, connected to one spark ball of an induction coil. The other spark ball is connected to the outside of the Leyden jar or

* G. Marconi, 'Syntonic Wireless Telegraphy,' *Journal of the Society of Arts*, Vol. XLIX., p. 501, 1901.

condenser through the primary coil of a transformer of a particular kind, called an oscillation transformer (see Fig. 9). The spark balls are brought within a few millimeters of each other. When the coil is set in operation, the jar is charged and discharged through the spark gap, and electrical oscillations are set up in the circuit consisting of the dielectric of the jar, the primary coil of the oscillation transformer and the spark gap. The secondary circuit of this oscillation transformer is connected in between the earth and the insulated aerial wire; hence when the oscillations take place in the primary circuit, they induce other oscillations in the aerial circuit. But the arrangement is not very effective unless, as is shown by Mr. Marconi, the two circuits of the oscillation transformer are tuned together.

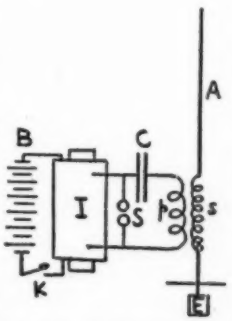


FIG. 9. MARCONI-BRAUN SYSTEM OF INDUCING ELECTROMOTIVE FORCE IN AN AERIAL *A*. *B*, battery; *K* key, *I*, induction coil; *S* spark gap; *C*, Leyden jar; *E*, earth plate; *ps*, oscillation transformer.

We shall return presently to the consideration of this form of transmitter; meanwhile, we may notice that by means of such an arrangement it is possible to create in the aerial a far greater charging electromotive force than would be the case if the aerial were connected directly to one terminal of the secondary circuit of the induction coil, the other terminal being to earth, and the two terminals connected as usual by spark balls. By the inductive arrangement it is possible to create in an aerial electromotive forces which are equivalent to a spark of a foot in length, and when the length of the aerial is also properly proportioned, the potential along it will increase all the way up, until at the top or insulated end of the aerial it may reach an amount capable of giving sparks several feet in length. From the remarks already made on the analogy between the closed organ-pipe and the Marconi aerial wire, it will be seen that the wave which is radiated from the aerial must have a wave length four times that of the aerial, if the aerial is vibrating in its fundamental manner. It is also possible to create electrical oscillations in a vertical wire which are the harmonics of the fundamental.

All musicians are aware that in the case of an organ-pipe, if the pipe is blown gently it sounds a note which is called the fundamental of the pipe. The celebrated mathematician, Daniel Bernouilli, discovered that an organ-pipe can be made to yield a succession of musical notes by properly varying the pressure of the current of air blown into it. If the pipe is an open pipe, and if we call the frequency of the primary note obtained when the pipe is gently blown, unity, then when we blow more strongly, the pipe yields notes which are the

harmonics of the fundamental one; that is to say, notes which have frequencies represented by the numbers 2, 3, 4, 5, etc. If, however, the pipe is closed at the top, then over-blowing the pipe makes it yield the odd harmonics or the tones which are related to the primary tone in the ratio of 3, 5, 7, etc., to unity. Accordingly, if a stopped pipe gives as its fundamental the note C, its first overtone will be the fifth above the octave or G′.

As already remarked, the aerial wire or radiator as used in Marconi telegraphy may be looked upon as a kind of ether organ-pipe or siren tube, and its electrical phenomena are in every respect similar to the acoustic phenomena of the ordinary closed organ-pipe. When the aerial is sounding its fundamental ether note, the conditions which pertain are that there is a current flowing into the aerial at the lower end, but at that point the variation in potential is very small, whereas at the upper end there is no current but the variations of potential are very large. Accordingly, we say that at the upper end of the aerial there is an antinode of potential and a node of current, and at the bottom, an antinode of current and a node of potential. By altering the frequency of the electrical impulses we can create in the aerial an arrangement of nodes of current or potential corresponding to the overtones of a closed organ-pipe. But whatever may be the arrangement, the conditions must always hold, that there is a node of current at the upper end and an antinode of current at the lower end. In other words, there are large variations of current at the place where the aerial terminates on the spark gap and no current at the upper end. The first harmonic is formed where there is a node of potential at one third of the length of the aerial from the top. In this case, we have a node of potential not only at the lower end of the wire, but at two thirds of the way up. In the same way we can create in the closed organ-pipe by properly overblowing the pipe, a region about two thirds of the way up the pipe, where the pressure changes in the air are practically no greater than they are at the mouthpiece. We can make evident visually in a beautiful manner the existence of similar stationary electrical waves in an aerial by means of an ingenious arrangement devised by Dr. Georg Seibt, of Berlin. It consists of a very long, silk covered copper wire *A* (see Fig. 10) wound in a close spiral of single layer round a wooden rod six feet long and about two inches in diameter. This rod is insulated, and at the lower end the wire is connected to a Leyden jar circuit, consisting of a Leyden jar or jars and an inductance coil *L*, the inductance of which can be varied. Oscillations are set up in this jar circuit by means of an induction coil discharge, and the lower end of the long spiral wire is attached to one point on the jar circuit. In this manner we can communicate to the bottom end of the long spiral wire a series of electric

impulses, the time period of which depends upon the capacity of the jar and the inductance of the discharge circuit. We can, moreover, vary this frequency over wide limits. Parallel to the long spiral wire is suspended another copper wire *E* (see Fig. 10), and between this wire and the silk-covered copper wire discharges take place due to the potential difference between each part of the wire and this long aerial wire. If we arrange matters so that the impulses communicated to the bottom end of the long spiral wire correspond to its fundamental note or periodic time, then in a darkened room we shall see a luminous glow or discharge between the vertical wire and the spiral wire, which increases in intensity all the way up to the top of the spiral wire. The luminosity of this brush discharge at any point is evidence of the potential of the spiral wire at that point, and its distribution clearly demonstrates that the difference of potential between the spiral wire and the aerial increases all the way up from the bottom to the top of the spiral wire. In the next place, by making a little adjustment and by varying the inductance of the jar circuit, we can increase the frequency of the impulses which are falling upon the spiral wire; and then it will be noticed that the distribution of the brush discharge or luminosity is altered, and that there is a maximum now at about one third of the height of the spiral wire, and a dark place at about two thirds of the height, and another bright place at the top, thus showing that we have a node of potential at about two thirds the way up the wire (see Fig. 11), and we have therefore set up in the spiral wire electrical oscillations corresponding to the first overtone. It is possible to show in the same way the existence of the second harmonic in the coil, but the luminosity then becomes too faint to be seen at a distance.

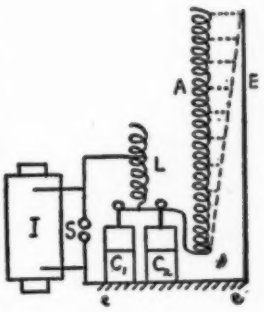


FIG. 10. SEIBT'S APPARATUS FOR SHOWING STATIONARY WAVES IN LONG SOLENOID *A*. *I*, induction coil; *S*, spark gap *L*, inductance coil; $C_1 C_2$, Leyden jars; *E*, earth wire.

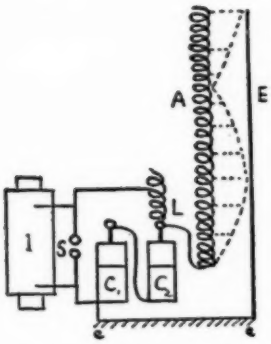


FIG. 11. HARMONIC OSCILLATIONS IN LONG SOLENOID SHOWN WITH SEIBT'S APPARATUS.

An interesting form of aerial devised by Professor Slaby, of Berlin, depends for its action entirely on the fact that the electrical oscillations set up in it which radiate are harmonics of the fundamental tone.

A closed vertical loop A_1A_2 (see Fig. 12) is formed by erecting two parallel insulated wires vertically a few feet apart and joining them together at the top. At the bottom these wires are connected, with the secondary terminals of an induction coil, a condenser C or Leyden jar being bridged across the terminals and a pair of spark balls S inserted in one side of the loop. It will readily be seen that on setting the coil in action, oscillations will take place in these vertical wires, but that if the oscillations are simply the fundamental note of the system, then at any moment corresponding to a current going up one side of the loop of wire, there must be a current coming down the other. Accordingly, an arrangement of this kind, forming what is called a closed circuit, will not radiate or radiates but very feebly. Professor Slaby found, however, that it might be converted into a powerful radiator if we give the two sides of the loop unequal capacity or inductance, and at the same time earth one of the lower ends of the loop, as shown in Fig. 13. By this means it is possible to set up in the loop electrical overtones or harmonics of the fundamental oscillation, and if we cause the system to vibrate so as to produce its first odd harmonic, there is a potential node at the lower end of both vertical sides of the loop, a potential node on both vertical sides at two thirds of the way up, and a potential antinode at the summit of the loop; then, under these circumstances, the closed loop of wire is in the same electrical condition as if two simple Marconi aerials, both emitting their first odd harmonic oscillation, were placed side by side and joined together at the top.

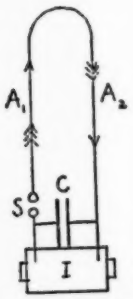


FIG. 12 NON-RADIATIVE CLOSED LOOP AERIAL.

It is a little difficult without the employment of mathematical analysis to explain precisely the manner in which earthing one side of the loop or making the loop unsymmetrical as regards inductance has the effect of creating overtones in it. The following rough illustration may, however, be of some assistance. Imagine a long spiral metallic spring supported horizontally by threads. Let this represent a conductor, and let any movement to or fro of a part of the spring represent a current in that conductor. Suppose we take hold of the spring at one end, we can move it bodily to and fro as a whole. In this case, every part of the spring is moving one way or the other in the same manner at the same time. This corresponds with the case in which the discharge of the condenser through the uniform loop con-

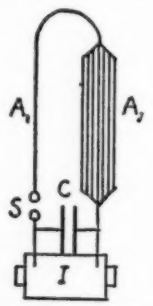


FIG. 13. SLABY'S LOOP RADIATOR.

ductor is a flow of electricity, all in one direction one way or the other. The current is in the same direction in all parts of the loop at the same time, and, therefore, if the current is going up one side of the loop it is at the same time coming down the other side. Hence the two sides of the loop are always in exact opposition as regards the effect of the current in them on the external space, and the loop does not radiate. Returning again to the case of the spring. Supposing that we add a weight to one end of the spring by attaching to it a metal ball, and then move the other end to and fro with certain periodic motion, it will be found quite easy to set up in the spring a pulsatory motion resembling the movement of the air in an open organ-pipe. Under these circumstances both ends of the spring will be moving inwards or outwards at the same time, and the central portions of the spring, although being pressed and expanded slightly, are moving to and fro very little. This corresponds in the case of the looped aerial with a current flowing up or down both sides at the same time; in other words, when this mode of electrical oscillation is established in the loop, its electrical condition is just that of two simple Marconi aerials joined together at the top and vibrating in their fundamental manner. Accordingly, if one side of the double loop is earthed, we then have an arrangement which radiates waves. Professor Slaby found that by giving one side of the loop less inductance than the other, and at the same time earthing the side having greater inductance at the bottom, he was able to make an arrangement which radiated, not in virtue of the normal oscillations of the condenser, but in virtue of the harmonic oscillations set up in the conductor itself. The mathematical theory of this radiator has been very fully developed by Dr. Georg Seibt.

It will be seen, therefore, that there are several ways in which we may start into existence oscillations in an aerial. First, the aerial may be insulated, and we may charge it to a high potential and allow this charge suddenly to rush out. Although this process gives rise to a disturbance in the ether, as already explained, it is analogous to a pop or explosion in the air, rather than to a sustained musical note. The exact acoustic analogue would be obtained if we imagine a long pipe pumped full of air and then suddenly opened at one end. The air would rush out, and, communicating a blow to the outer air, would create an atmospheric disturbance appreciated as a noise or small explosion. This is what happens when we cut the string and let the cork fly out from a bottle of champagne. At the same time, the inertia of the air rushing out of the tube would cause it to overshoot the mark, and a short time after opening the valve the tube, so far from containing compressed air, would contain air slightly rarefied near its mouth, and this rarefication would travel back up the tube in the form of

wave motion, and, being reflected as condensation at the closed end, travel down again; and so after being reflected once or twice at the open or closed end, become damped out very rapidly in virtue of both air friction and the radiation of the energy. In the case, however, of the ordinary organ-pipe, we do not depend merely upon a store of compressed air put into the pipe, but we have a store of energy to draw upon in the form of the large amount of compressed air contained in a wind chest, which is being continually supplied by the bellows. This store of compressed air is fed into the organ-pipe with the result that we obtain a continuous radiation of sound waves. The first case, in which the only store of energy is the compressed air originally contained in the pipe, illustrates the operation of the simple Marconi aerial. The second case, in which there is a larger store of energy to draw upon, the organ-pipe being connected to a wind chest, illustrates the Marconi-Braun method in which an aerial is employed to radiate a store of electric energy contained in a condenser, gradually liberated by the aerial in the form of a series of electrical oscillations and waves. In this arrangement the condenser corresponds to the wind chest, and it is continually kept full of electrical energy by means of the induction coil or transformer, which answers to the bellows of the organ. From the condenser, electrical energy is discharged each time the spark discharge passes at a spark gap in the form of electrical oscillations set up in the primary circuit of an oscillation transformer. The secondary circuit of this transformer is connected in between the earth and the aerial, and therefore may be considered as part of it, and, accordingly, the energy which is radiated from the aerial is not simply that which is stored up in it in virtue of its own small capacity, but that which is stored up in the much larger capacity represented by the primary condenser or, as it may be called, the electrical wind chest. By the second arrangement we have therefore the means of radiating more or less continuous trains of electric waves, corresponding with each spark discharge. To create powerful oscillations in the aerial, one condition of success is that there shall be an identity in time-period between the circuit of the aerial and that of the primary condenser. The aerial is an open circuit which has capacity with respect to the earth, and it has also inductance, partly due to the wire of the aerial and partly due to the secondary circuit of the oscillation transformer in series with it. The primary circuit or spark circuit has capacity, viz., the capacity of the energy-storing condenser, and it has also inductance, viz., the inductance of the primary circuit of the oscillation transformer. We shall consider at a later stage more particularly the details of syntonising arrangements, but meanwhile it may be said that one condition for setting up powerful waves by means of the above arrangement is

that the electrical time-period of both the two circuits mentioned shall be the same. This involves adjusting the inductance and capacity so that the product of conductance and capacity for each of these two circuits is numerically the same. Instead of employing an oscillation transformer between the condenser circuit and the aerial, the aerial may be connected directly to some point on the condenser circuit at which the potential oscillations are large, and we have then another arrangement devised by Professor Braun (see Fig. 14). In this case, in order to accumulate large potential oscillations at the top of the aerial, it is, as we have seen, necessary that the length of the aerial shall be one quarter the length of the wave. If therefore the electrical oscillations in the condenser circuit are at the rate of N per second, in other words, have a frequency N, the wave-length corresponding to this frequency is given by the expression,

$$3 \times 10^{10}/N \text{ cms.}$$

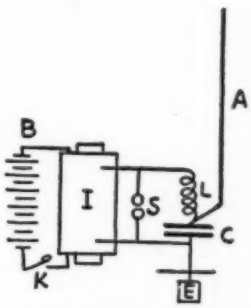


FIG. 14. BRAUN'S RADIATOR. *B*, battery; *I*, induction coil; *K*, key; *S*, spark gap; *L*, inductance coil; *C*, condenser *A*, aerial.

The number 3×10^{10} is the value in centimeters per second of the velocity of the electromagnetic wave, and is identical with that of light. The corresponding resonant length of the aerial is therefore one fourth of this wave-length, or $3 \times 10^{10}/4N$. Generally speaking, however, it will be found that with any length of aerial which is practicable, say 200 feet or 6,000 cms., this proportion necessitates rather a high frequency in the primary oscillation circuit. In the case considered, viz., for an aerial 200 feet in height, the oscillations in the primary circuit must have a frequency of one and a quarter million. This high frequency can only be obtained either by greatly reducing the inductance of the primary discharge circuit, or reducing the capacity. If we reduce the capacity, we thereby greatly reduce the storage of energy, and it is not practicable to reduce the inductance below a certain amount.

Summing up, it may be said that there are three, and as far as the writer is aware, at present only three, modes of exciting the electrical oscillations in an aerial wire. First, the aerial may itself be used as an electrical reservoir and charged to a high potential and suddenly discharged to the earth. This is the original Marconi method. The second method, due to Braun, consists of attaching the aerial to some point on an oscillation circuit consisting of a condenser, an inductance coil and a spark gap, in series with one another, and charging and

discharging the condenser across the spark gap so as to create alterations of potential at some point on the oscillation circuit. The length of the aerial must then be so proportioned as above described that it is resonant to this frequency. Thirdly, we may employ the arrangement involving an oscillation transformer, in which the oscillations in the primary condenser circuit are made to induce others in the aerial circuit, the time-period of the two circuits being the same. This method may be called the Braun-Marconi method. Professor Slaby has combined together in a certain way the original Marconi simple aerial with the resonant quarter-wave-length wire of Braun. He constructs what he calls a *multiplicator,* which is really a wire wound into a loose spiral connected at one point to an oscillation circuit consisting of a condenser inductance, the length of this wire being proportioned so that there is a great resonance or multiplication of tension or potential at its free end. This free end is then attached to the lower end of an ordinary Marconi aerial, and serves to charge it with a higher potential than could be obtained by the use of the induction coil directly attached to it.

(To be continued.)

PHYSIOLOGICAL ECONOMY IN NUTRITION.

By RUSSELL H. CHITTENDEN,

DIRECTOR OF THE SHEFFIELD SCIENTIFIC SCHOOL OF YALE UNIVERSITY.

AMONG the many problems awaiting solution, none is of greater importance for the welfare of the individual and of the race than that which relates to the proper nutrition of the body. Man eats to live and to gain strength for his daily work, and without sufficient nutriment the machinery of the body can not be run smoothly or with proper efficiency. The taking of an excess of food, on the other hand, is just as harmful as insufficient nourishment, involving as it does not only wasteful expenditure, but what is of even greater moment, an expenditure of energy on the part of the body, which may in the long run prove disastrous. While it is the function of food to supply the material from which the body can derive the necessary energy for its varied activities, any excess of food over and above what is needed to make good the loss incidental to life and daily activity is just so much of an incubus, which is bound to detract from the smooth running of the machinery and to diminish the fitness of the body for performing its normal functions.

A proper physiological condition begets a moral, mental and physical fitness which can not be attained in any other way. Further, it must be remembered that lack of a proper physiological condition of the body is more broadly responsible for moral, social, mental and physical ills than any other factor that can be named. Poverty and vice on ultimate analysis may often be traced to a perversion of nutrition. A healthy state of the body is a necessary concomitant of mental and moral vigor, as well as of physical strength. Abnormal methods of living are often the accompaniment or forerunner of vicious tastes that might never have been developed under more strictly physiological conditions. Health, strength (mental and physical) and moral tone alike depend upon the proper fulfilment of the laws of nature, and it is the manifest duty of a people hoping for the fullest development of physical, mental and moral strength to ascertain the character of these laws with a view to their proper observance. Poverty, crime, physical ills and a blunted or perverted moral sense are the penalties we may be called upon to pay for the disobedience of nature's laws; penalties which not only *we* may have to pay, but which may be passed down to succeeding generations, thereby influencing the lives of those yet unborn.

There is to-day great need for a thorough physiological study of

those laws of nutrition which constitute the foundation of good living. It is a subject full of interest and promise for the sociologist and economist, as well as for the physiologist. We need a far more complete knowledge than we possess at present of the laws governing nutrition; we need fuller knowledge of the methods by which the most complete, satisfactory and economical utilization of the diet can be obtained; we need to know more concerning the minimum diet and the minimum amount of proteid or albuminous foods on which health, mental and physical vigor can be permanently maintained; we need to know more fully concerning the influence of various forms of food on growth and recuperative power; we need more complete knowledge regarding the rôle of various dietetic and digestive habits, fixed or acquired; the effects of thorough mastication, insalivation and the influence of two versus three meals a day upon the utilization of food and hence upon the bodily health. Further, we need more concise information as to the effect of the mental state upon digestion and nutrition. These and many other problems of a like nature confront us when we attempt to trace the influence of a proper nutrition upon the condition of the body. These problems, however, all admit of solution, and in their solution undoubtedly lies the remedy for many of the personal ills of mankind.

The foregoing thoughts have been suggested by observations recently made in the writer's laboratory on the amount and character of the food actually required by a healthy man in the maintenance of bodily equilibrium in periods of rest and physical work. Our ideas at present are based primarily upon observations as to what civilized peoples are accustomed to do, and not upon what they need to do in order to meet the demands made upon the body. Sir William Roberts has well said that the palate is the dietetic conscience, but he adds that there are many misfit palates, and we may well query whether our dietetic consciences have not become generally perverted through a false mode of living. The well-nigh universal habit of catering to our appetite on all occasions, of bowing to the fancied dictates of our palates even to the extent of satiety, and without regard to the physiological needs of the body, may quite naturally have resulted in a false standard of living in which we have departed widely from the proper laws of nutrition. Statistical studies carried out on large groups of individuals by various physiologists have led to the general acceptance of dietary standards, such as those proposed by Voit of Munich, and Atwater in this country. Thus the Voit diet for a man doing moderate work is 118 grams of proteid or albuminous food, 56 grams of fat and 500 grams of carbohydrates, such as sugar and starch, with a total fuel value of 3,055 large calories or heat units per day. With hard work, Voit increases the daily requirement to 145 grams of proteid, 160 grams of fat and 450 grams of carbohydrates, with a total

fuel value of 3,370 large calories. Atwater, on the other hand, from his large number of observations, is inclined to place the daily proteid requirement at 125 grams, with sufficient fat and carbohydrate to equal a total fuel value of 3,500 large calories for a man doing a moderate amount of work; while for a man at hard work the daily diet is increased to 150 grams of proteid, and with fats and carbohydrates to yield a total fuel value of 4,500 large calories. These standards are very generally accepted as being the requirement for the average individual under the given conditions of work, and it may be that these figures actually represent the daily needs of the body. Suppose, on the other hand, that we have in these figures false standards, or, in other words that the quantities of foodstuffs called for are altogether larger than the actual demands of the body require. In this case there is a positive waste of valuable food material which we may calculate in dollars and cents; a loss of income incurred daily which might be expended more profitably in other directions. To the wage-earner with a large family, who must of necessity husband his resources, there is in our hypothesis a suggestion of material gain not to be disregarded. The money thus saved might be expended for the education of the children, for the purchase of household treasures tending to elevate the moral and mental state of the occupants, or in many other ways that the imagination can easily supply. This kind of saving, however, is purely a question of economy, and in some strata of society would be objected to as indicative of a condition of sordidness. It has come to be a part of our personal pride to have a well-supplied table, and to eat largely and freely of the good things provided. The poorer man takes pride in furnishing his family with a diet rich in expensive articles of food, and imagines that by so doing he is inciting them to heartier consumption and to increased health and strength. He would be ashamed to save in this way, under the honest belief that by so doing he might endanger the health of his dear ones. But let us suppose that this hypothetical waste of food is not merely uneconomical, that it is undesirable for other and weightier reasons. Indeed, let us suppose that this unnecessary consumption of food is distinctly harmful to the body, that it is physiologically uneconomical, and that in our efforts to maintain a high degree of efficiency we are in reality putting upon the machinery of the body a heavy and entirely uncalled for strain which is bound to prove more or less detrimental. If there is truth in this assumption, our hypothesis takes on a deeper significance, and we may well inquire whether there are any reasonable grounds for doubting the accuracy of our present dietary standards.

In this connection it is to be remembered that the food of mankind may be classified under three heads, viz., *proteid or albuminous*, such as meat, eggs, casein of milk, gluten of bread and various vege-

table proteids; *carbohydrates,* as sugar and the starches of our cereals, and *fats,* including those of both animal and vegetable origin. The proteids are characterized by containing nitrogen (about 16 per cent.), while the fats and carbohydrates contain only carbon, hydrogen and oxygen. The two latter classes of foodstuffs are burned up in the body, when completely utilized, to carbonic acid (a gas) and water, while the proteid foods beside yielding carbonic acid and water give off practically all of their nitrogen in the form of crystalline nitrogenous products in the excreta of the body. Proteid foods have a particular function to perform, viz., to supply the waste of proteid matter from the active tissues of the body, and this function can be performed only by the proteid foods, hence the latter are essential foodstuffs without which the body can not long survive. Fats and carbohydrates, on the other hand, are mainly of value for the energy they yield on oxidation, and in this connection it is to be remembered that the fuel value of fats per gram is much larger than that of carbohydrates, viz., 9.3:4.1, or more than twice as great. Further, it is to be noted that the various foodstuffs can not be utilized directly by the body, but they must first be digested, then absorbed and assimilated, after which they gradually, in their changed form, undergo decomposition with liberation of their contained energy which may manifest itself in the form of heat or of mechanical work. The thoroughness with which foods are digested and utilized in the body must therefore count for a great deal in determining their dietetic or nutritive value. Moreover, it is easy to see how an excess of proteid food will give rise to a large proportion of nitrogenous waste matter, which floating through the system prior to excretion may by acting on the nervous system and other parts of the body produce disagreeable results. A mere excess of food, even of the non-nitrogenous variety, must entail a large amount of unnecessary work, thereby using up a proportional amount of energy for its own disposal, since once introduced into the body it must be digested and absorbed, otherwise it undergoes fermentation and putrefaction in the stomach and intestines, causing countless troubles. When absorbed in quantities beyond the real needs of the body, it may be temporarily deposited as fat, but why load up the system with unnecessary material, thereby interfering with the free running of the machinery? In other words, it is very evident that the taking in of food in quantities beyond the physiological requirements is undesirable and may prove exceedingly injurious. It is truly uneconomical and defeats the very ends we aim to attain. Instead of adding to the bodily vigor and increasing the fitness of the organism to do its daily work, we are really hampering the delicate mechanism upon the smooth running of which so much depends.

Why now should we assume that a daily diet of over 100 grams of proteid, with fats and carbohydrates sufficient to make up a fuel

value of over 3,000 large calories, is a necessary requisite for bodily vigor and physical and mental fitness? Mainly because of the supposition that true dietary standards may be learned by observing the relative amounts of nutrients actually consumed by a large number of individuals so situated that the choice of food is unrestricted. But this does not constitute very sound evidence. It certainly is not above criticism. We may well ask ourselves whether man has yet learned wisdom with regard to himself, and whether his instincts or appetites are to be entirely trusted as safe guides to follow in the matter of his own nutrition. The experiments of Kumagawa, Sivén and other physiologists, have certainly shown that men may live and thrive, for a time at least, on amounts of proteid per day equal to only one half and one quarter the amount called for in the Voit standard. Sivén's experiments, in particular, certainly indicate that the human organism can maintain itself in nitrogenous equilibrium with far smaller amounts of proteid in the diet than is ordinarily taught, and further, that this condition can be attained without unduly increasing the total calories of the food intake. Such investigations, however, have always called forth critical comment from writers on nutrition, indicating a reluctance to depart from the current doctrines of the Voit or Munich school, and, indeed, it may justly be claimed that the ordinary nutrition experiments, extending over short periods of time, are not entirely adequate to prove the effect of a given set of conditions when the latter are continued for months or years. Thus, Schäfer writes: "It may be doubted whether a diet which includes considerably less proteid than 100 grams for the twenty-four hours could maintain a man of average size and weight for an indefinite time. It has frequently been asserted that many Asiatics consume a very much smaller proportion of proteid than is the case with Europeans. The inhabitants of India, Japan and China chiefly consume rice as the normal constituent of their diet, which contains relatively little proteid; and this has been advanced as an argument in favor of the view that the minimal amount of proteid is much less than that ordinarily given as essential to the maintenance of nutritive equilibrium. It must, however, be stated that we have no definite statistics to show that, in proportion to their body-weight, Asiatics doing the same amount of work as Europeans require a less amount of proteids; indeed such evidence as is forthcoming is rather in favor of the opposite view." This statement is typical of the attitude of physiologists in general on this important subject. Why not candidly admit that the matter is in doubt, and with a due recognition of the importance of the subject attempt to ascertain the real truth of the matter?

The writer has had in his laboratory for several months past a gentleman (H. F.) who has for some five years, in pursuit of a study

of the subject of human nutrition, practised a certain degree of abstinence in the taking of food and attained important economy with, as he believes, great gain in bodily and mental vigor and with marked improvement in his general health. Under his new method of living he finds himself possessed of a peculiar fitness for work of all kinds and with freedom from the ordinary fatigue incidental to extra physical exertion. In using the word abstinence possibly a wrong impression is given, for the habits of life now followed have resulted in the disappearance of the ordinary craving for food. In other words, the gentleman in question fully satisfies his appetite, but no longer desires the amount of food consumed by most individuals.

For a period of thirteen days, in January, he was under observation in the writer's laboratory, his excretions being analyzed daily with a view to ascertaining the exact amount of proteid consumed. The results showed that the average daily amount of proteid metabolized was 41.25 grams, the body-weight (165 pounds) remaining practically constant. Especially noteworthy also was the very complete utilization of the proteid food during this period of observation. It will be observed here that the daily amount of proteid food taken was less than one half that of the minimum Voit standard, and it should also be mentioned that this apparent deficiency in proteid food was not made good by any large consumption of fats or carbohydrates. Further, there was no restriction in diet. On the contrary, there was perfect freedom of choice, and the instructions given were to follow his usual dietetic habits. Analysis of the excretions showed an output of nitrogen equal to the breaking down of 41.25 grams of proteid per day, as an average, the extremes being 33.06 grams and 47.05 grams of proteid.

In February, a more thorough series of observations was made, involving a careful analysis of the daily diet, together with analysis of the excreta, so that not alone the proteid consumption might be ascertained, but likewise the total intake of fats and carbohydrates. The diet consumed was quite simple, and consisted merely of a prepared cereal food, milk and maple sugar. This diet was taken twice a day for seven days, and was selected by the subject as giving sufficient variety for his needs and quite in accord with his taste. No attempt was made to conform to any given standard of quantity, but the subject took each day such amounts of the above foods as his appetite craved. Each portion taken, however, was carefully weighed in the laboratory, the chemical composition of the food determined, and the fuel value calculated by the usual methods.

The following table gives the daily intake of proteids, fats and carbohydrates for six days, together with the calculated fuel value, and also the nitrogen intake, together with the nitrogen output through the excreta. Many other data were obtained showing diminished

excretion of uric acid, ethereal sulphates, phosphoric acid, etc., but they need not be discussed here.

	Intake.					Output of Nitrogen.		
	Proteids.	Fats.	Carbohy.	Calories.	Nitrogen.	Urine.	Fæces.	Total.
	Grams.	Grams.	Grams.		Grams.	Grams.	Grams.	Grams.
Feb. 2	31.3	25.3	125.4	900	5.02	5.27	0.18	5.45
3	46.8	40.4	266.2	1690	7.50	6.24	0.81*	7.05
4	48.0	38.1	283.0	1747	7.70	5.53	0.81*	6.34
5	50.0	40.6	269.0	1711	8.00	6.44	0.81*	7.25
6	47.0	41.5	267.0	1737	7.49	6.83	0.81*	7.64
7	46 5	39.8	307.3	1852	7.44	7.50	0.17	7.67
Daily Av.	44.9	38.0	253.0	1606	7.19	6.30	0.60	6.90

The main things to be noted in these results are, first, that the total daily consumption of proteid amounted on an average to only 45 grams, and that the fat and carbohydrate were taken in quantities only sufficient to bring the total fuel value of the daily food up to a little more than 1,600 large calories. If, however, we eliminate the first day, when for some reason the subject took an unusually small amount of food, these figures are increased somewhat, but they are ridiculously low compared with the ordinarily accepted dietary standards. When we recall that the Voit standard demands at least 118 grams of proteid and a total fuel value of 3,000 large calories daily, we appreciate at once the full significance of the above figures. But it may be asked, was this diet at all adequate for the needs of the body—sufficient for a man weighing 165 pounds? In reply, it may be said that the appetite was satisfied and that the subject had full freedom to take more food if he so desired. To give a physiological answer, it may be said that the body-weight remained practically constant throughout the seven days' period, and further, it will be observed by comparing the figures of the table that the nitrogen of the intake and the total nitrogen of the output were not far apart. In other words, there was a close approach to what the physiologist calls nitrogenous equilibrium. In fact, it will be noted that on several days the nitrogen output was slightly less than the nitrogen taken in. We are, therefore, apparently justified in saying that the above diet, simple though it was in variety, and in quantity far below the usually accepted requirement, was quite adequate for the needs of the body. In this connection it may be asked, what were the needs of the body during this seven days' period? This is obviously a very important point. Can a man on such a diet, even though it suffices to keep up body-weight and apparently also physiological equilibrium, do work to any extent? Will there be under such condition a proper degree of fitness for physical work of any kind? In order to ascertain this

* Average of the four days.

point, the subject was invited to do physical work at the Yale University Gymnasium and placed under the guidance of the director of the gymnasium, Dr. William G. Anderson. The results of the observations there made are here given, taken verbatim from Dr. Anderson's report to the writer.

> On the 4th, 5th, 6th and 7th of February, 1903, I gave to Mr. Horace Fletcher the same kind of exercises we give to the Varsity Crew. They are drastic and fatiguing and can not be done by beginners without soreness and pain resulting. The exercises he was asked to take were of a character to tax the heart and lungs as well as to try the muscles of the limbs and trunk. I should not give these exercises to Freshmen on account of their severity.
>
> Mr. Fletcher has taken these movements with an ease that is unlooked for. He gives evidence of no soreness or lameness and the large groups of muscles respond the second day without evidence of being poisoned by Carbon dioxide. There is no evidence of distress after or during the endurance test, *i. e.*, the long run. The heart is fast but regular. It comes back to its normal beat quicker than does the heart of other men of his weight and age.
>
> The case is unusual and I am surprised that Mr. Fletcher can do the work of trained athletes and not give marked evidences of over exertion. As I am in almost constant training I have gone over the same exercises and in about the same way and have given the results for a standard of comparison. [The figures are not given here.]
>
> My conclusion given in condensed form is this. Mr. Fletcher performs this work with greater ease and with fewer noticeable bad results than any man of his age and condition I have ever worked with.

To appreciate the full significance of this report, it must be remembered that Mr. Fletcher had for several months past taken practically no exercise other than that involved in daily walks about town.

In view of the strenuous work imposed during the above four days, it is quite evident that the body had need of a certain amount of nutritive material. Yet the work was done without apparently drawing upon any reserve the body may have possessed. The diet, small though it was, and with only half the accepted requirement in fuel value, still sufficed to furnish the requisite energy. The work was accomplished with perfect ease, without strain, without the usual resultant lameness, without taxing the heart or lungs, and without loss of body-weight. In other words, in Mr. Fletcher's case at least, the body machinery was kept in perfect fitness without the consumption of any such quantities of fuel as has generally been considered necessary.

Just here it may be instructive to observe that the food consumed by Mr. Fletcher during this seven days' period—and which has been shown to be entirely adequate for his bodily needs during strenuous activity—cost eleven cents daily, thus making the total cost for the seven days seventy-seven cents! If we contrast this figure with the amounts generally paid for average nourishment for a like period of time, there is certainly food for serious thought. Mr. Fletcher avers that he has followed his present plan of living for nearly five years; he usually takes two meals a day; has been led to a strong liking for

sugar and carbohydrates in general and away from a meat diet; is always in perfect health, and is constantly in a condition of fitness for work. He practises thorough mastication, with more complete insalivation of the food (liquid as well as solid) than is usual, thereby insuring more complete and ready digestion and a more thorough utilization of the nutritive portions of the food.

In view of these results, are we not justified in asking ourselves whether we have yet attained a clear comprehension of the real requirements of the body in the matter of daily nutriment? Whether we fully comprehend the best and most economical method of maintaining the body in a state of physiological fitness? The case of Mr. Fletcher just described; the results noted in connection with certain Asiatic peoples; the fruitarians and *nut*arians in our own country recently studied by Professor Jaffa, of the University of California; all suggest the possibility of much greater physiological economy than we as a race are wont to practise. If these are merely exceptional cases, we need to know it, but if, on the other hand, it is possible for mankind in general to maintain proper nutritive conditions on dietary standards far below those now accepted as necessary, it is time for us to ascertain that fact. For, if our standards are now unnecessarily high, then surely we are not only practising an uneconomical method of sustaining life, but we are subjecting ourselves to conditions the reverse of physiological, and which must of necessity be inimical to our well being. The possibility of more scientific knowledge of the natural requirements of a healthy nutrition is made brighter by the fact that the economic results noted in connection with our metabolism examination of Mr. Fletcher is confirmatory of similar results obtained under the direction and scrutiny of Sir Michael Foster at the University of Cambridge, England, during the autumn and winter of last year; and by Dr. Ernest Van Someren, Mr. Fletcher's *collaborateur,* in Venice, on subjects of various ages and of both sexes, some account of which has already been presented to the British Medical Association and to the International Congress of Physiologists at its last meeting at Turin, Italy. At the same time emphasis must be laid upon the fact that no definite and positive conclusions can be arrived at except as the result of careful experiments and observations on many individuals covering long periods of time. This, however, the writer hopes to do in the very near future, with the cooperation of a corps of interested observers.

The problem is far-reaching. It involves not alone the individual, but society as a whole, for beyond the individual lies the broader field of the community, and what proves helpful for the one will eventually react for the betterment of society and for the improvement of mankind in general.

THE FIELD OF MUNICIPAL HYGIENE.

By Professor EDWIN O. JORDAN,
UNIVERSITY OF CHICAGO.

THE modern disposition to revel in the general situation is met by those persons who are disinclined to take a consistently optimistic view of life with several sobering reflections. In regard to that conspicuous phenomenon of modern life, for example, the growth of large cities, attention has frequently been directed to the evil possibilities for the future of the race that are enwombed in city growth. Steady deterioration of mind and body, a tendency to movements of social unrest and disorder, increasingly unsanitary conditions of life are some of the elements in a widely-held belief that the massing or 'herding' of human beings in centers of population is a deplorable and distressing accompaniment of civilization.

It is often forgotten, however, both by those who lament the existence of great cities and by those who count with pride their tale of corn and oil and wine that in the last analysis not only the hope and salvation of the large city, but its growth and very existence depend upon the proper application of methods of municipal hygiene. We need hardly be reminded that many of the factors that make for a concentration of population have been operative in the past with quite as much force as they are to-day. The steady drift from the farm to the town is by no means a modern movement. In the course of the last three hundred years social philosophers have often had occasion to deplore the existence of a migration cityward and the so-called depopulation of the rural districts. In some countries, as in France in the eighteenth century, the chief danger in this movement was thought to lie in its evil effect upon the rural districts, and restrictive measures were advocated for the purpose of keeping a sufficient supply of labor upon the farms. In England the same current toward the cities was noticed, but different forebodings were aroused; the apprehension was expressed that the cities themselves might become unwieldy. Both Elizabeth and James I. issued proclamations forbidding migration into London because of the portentous dimensions that metropolis was thought to be assuming. In spite of the influx of immigrants, however, the actual growth of the large cities was slow if judged by modern standards. In the case of London there is reason to believe that the natural migration into the city was relatively greater two hundred and fifty years ago than it is to-day, and yet at that time its rate of increase was sluggish compared with the swift expansion of its population in the nineteenth century.

There can be no doubt that one reason why cities did not grow so rapidly in the seventeenth and eighteenth centuries as in the nineteenth is the excessively high death rate that prevailed during the earlier period. The flood of immigration, mighty as it was, did little more than make good the places of those citizens who fell victims to grievous sanitary conditions. From the facts that can be obtained it seems to have been universally true that almost up to the beginning of the nineteenth century the death rate of large cities exceeded the birth rate. This was not because the birth rate was abnormally low, but because the death rate was abnormally high. In the medieval city both birth rate and death rate were far higher than at present. Infant mortality must have mounted to a gruesome height. The uncleanliness and overcrowding of city dwellers, now largely relegated to the slums of our great cities, was the normal state of nearly all classes of society in the London and Paris of Louis and Elizabeth. Mr. Frederick Harrison has condensed into his own vigorous language the annals of many of the historians of the middle ages.

> **The old Greek and Roman religion of external cleanness was turned into a sin. The outward and visible sign of sanctity now was to be unclean. No one was clean, but the devout Christian was unutterably foul. The tone of the Middle Ages in the matter of dirt was a form of mental disease. Cooped up in castles and walled cities, with narrow courts and sunless alleys, they would pass day and night in the same clothes, within the same airless, gloomy, windowless, and pestiferous chambers; they would go to bed without night clothes, and sleep under uncleansed sheepskins and frieze rugs; they would wear the same leather, fur and woolen garments for a lifetime, and even for successive generations; they ate their meals without forks, and covered up the orts with rushes; they flung their refuse out of the window into the street or piled it up in the back-yard; the streets were narrow, unpaved, crooked lanes through which, under the very palace turrets, men and beasts tramped knee-deep in noisome mire. This was at intervals varied with fetid rivulets and open cesspools; every church was crammed with rotting corpses and surrounded with graveyards, sodden with cadaveric liquids, and strewn with disinterred bones. Round these charnel houses and pestiferous churches were piled old decaying wooden houses, their sole air being these deadly exhalations, and their sole water supply being these polluted streams or wells dug in this reeking soil. Even in the palaces and castles of the rich the same bestial habits prevailed. Prisoners rotted in noisome dungeons under the banqueting hall; corpses were buried under the floor of the private chapel; scores of soldiers and attendants slept in gangs for months together in the same hall or guard-room where they ate and drank, played and fought.**

The unsanitary conditions thus relentlessly portrayed must have had the same effect upon the health of all town inhabitants that similar conditions now exert upon the denizens of the 'crowded' and 'poor' wards of our modern cities.

So long as the city death rate exceeded the birth rate, the cities, in spite of the ceaseless thronging in of immigrants, could not grow as they have grown since. The economic equilibrium between town and country probably did not permit of any more considerable transfer of

population than actually occurred, and this transfer merely sufficed to keep the city population at a fairly constant level. As soon, however, as the city death rate began to decline and even to fall below the birth rate, the city population increased with leaps and bounds. This change is comparatively modern. London did not show a natural increase, due to excess of births, until the beginning of the nineteenth century, and Berlin did not reach this point until 1810.*

	Excess of Births.		Net	Total
	Number.	Percentage.	Immigration.	Increase.
1711–1815	—31,310	—0.2	1.4	1.2
1816–1837	23,505	0.5	1.3	1.8
1838–1858	55,513	0.7	1.6	2.3
1858–1875	95,460	0.8	3.2	4.0
1875–1895	189,240	1.1	1.6	2.7

It must not be forgotten, moreover, that simple excess of birth rate is not a fair measure of the decline that has occurred in the death rate. The birth rate itself has not remained constant, but in the last thirty years has materially diminished in nearly all civilized lands, so that in reality the decline in death rate is far greater than can be indicated by mere change in the absolute or proportional excess of births.

If the large cities have lost some of their former evil repute in the matter of healthfulness, the improvement must plainly be attributed to the development of the art of municipal hygiene. The dangers to health resulting from the massing of human beings within comparatively narrow limits are now fairly well known, but such knowledge has not always been available and is even now not always acted upon. The question of water supply affords a pregnant illustration. That some connection existed between outbreaks of disease and the character of drinking water was seen darkly all through the middle ages, but the groping speculations on the subject only led to the hypothesis, fraught with terrible consequences to an unhappy people, that 'the Jews had poisoned the wells.' It was not until about the middle of the last century (1854) that an explosion of cholera in London among the users of water from the 'Broad Street Pump' established definitely in the minds of physicians the truth that the specific poison of Asiatic cholera could be conveyed by means of infected drinking water. Some years later a similar conviction was reached regarding typhoid fever.

The medieval ignorance concerning the direct infectivity of drinking water and its importance as a factor in the spread of disease told heavily against the cities. In sparsely populated districts the likelihood that any particular well or spring would become infected was comparatively slight, and even if a single well did become accidentally polluted neighboring wells or springs used by other families might still

* A table is given by Kuczynski which shows the relative shares of immigration and excess of birth rate in producing the growth of Berlin.

remain entirely wholesome and incapable of spreading disease. The radius of infection was likely to be very circumscribed. In cities, on the other hand, where the persons resorting to a particular well might be very numerous,* the contamination of a single source could lead to disease and death, not merely in one or two families but in scores of families. Again, the greater liability to contamination to which a well in a densely settled region was exposed was an added menace and enhanced the peril to the city dweller from this source. The introduction of general public water supplies lessened to a considerable extent the latter evil and placed the city resident in a more advantageous position. The public water supply of large towns became on the whole purer than the water formerly obtainable by the private citizen, and since the supply was often brought from some distance, it was not liable to increased pollution as a direct consequence of the increase in the density of the city population. But on the other hand, the introduction of the public supply increased the danger from diffusion. Far greater numbers of people were affected. If the public supply became infected with a specific disease germ, the germ was distributed among much wider circles, and the infection became a momentous matter to the whole community. This in turn had the natural result that the attention formerly directed by the more intelligent members of the community to the care of their own private water supplies was now turned towards the public supply, and the problems of expert selection, supervision and control of the public supply began to receive the attention they deserved. There remained in many municipalities, however, so much inertia that this obvious duty was neglected or abandoned to the tender mercies of greedy politicians.

The conditions in many parts of the United States at the present day testify eloquently to the existence of this transition stage. In those sections, however, where it is the rule for proper care to be taken of the public water supplies the city death rate from typhoid fever is low, often lower in fact than in the surrounding country districts. In the year 1900, for instance, the typhoid fever death rate in the thickly populated 'Maritime District' of New York State, comprising chiefly the territory of Greater New York, with a population density of 1,535 per square mile, was only 2.0 per 10,000 inhabitants, while in the sparsely settled 'Adirondacks and Northern' district, with a population per square mile of 26, the reported death rate from typhoid fever was almost twice as great (3.9).

Theoretically, at least, the city ought to possess a decided advantage over the country in the matter of water supply. It ought to be possible for a large city to place its public supply under expert and specialized control, thus averting from the ignorant and careless members of

* At least 137 persons were known to have drunk water from the Broad Street pump shortly before the outbreak of cholera in 1854.

the community the consequences that would otherwise follow their ignorance and neglect. In other words, the quality of a public water supply ought easily to be better than the average water supply that would be obtained by the average citizen for himself under rural conditions. If the real situation is sometimes otherwise it is not because impure water is one of the necessary and inevitable accompaniments of city life, but because the city has failed to avail itself of the superior resources at its disposal.

The matter of water supply is not the only respect in which the city should possess a practical advantage. The opportunities for speedy and efficient treatment of many acute diseases are greater in a large and compact community than in one sparsely settled. Well-equipped hospitals and dispensaries, the most expert surgeons, the best trained nurses are all most likely to be found in the centers of population. Many city families have experienced the increased anxiety and danger that accompany a case of serious illness occurring when the family is away for the summer in a little country town. The careful nursing and the timely and expert treatment which even those in moderate circumstances can command in a large city are quite out of the reach of the majority of rural dwellers.

In addition to the advantages that accrue to the city dweller from opportunities for a particularly efficient treatment of disease in general, there are certain specific instances where early diagnosis and prompt treatment of a particular malady may suffice to turn the scale in favor of the patient. A notable example is presented in the case of diphtheria. All the larger cities and most of the smaller ones have in recent years provided themselves with well-equipped municipal laboratories in which microscopical and cultural examinations are freely made at the request of any physician. By the utilization in this way of the best modern appliances and methods and of experienced and specially qualified service, it is possible in the majority of cases for the physician to discover within twenty-four hours whether his patient is infected with the virulent diphtheria bacillus or is merely suffering from an ordinary and only remotely dangerous sore throat. The importance of an early diagnosis in the case of diphtheria is supreme for the reason that the administration of the diphtheria antitoxin is most likely to prove successful in the early stages of the disease. The antitoxin can not repair any damage that may have been done to the tissues of the body, but can only neutralize and render harmless the diphtheritic poison that is circulating in the blood. If the presence of a true diphtheritic infection is not recognized until late in the course of the disease the injection of the antitoxin may have little influence upon the outcome, since the heart and other organs may have suffered irreparable injury before the nature of the disease becomes understood. It is of the utmost importance, therefore, for the physician to

recognize the existence of diphtheria and to be in a position to employ without delay the specific remedy. In this respect the city physician is at a distinct advantage in treating diphtheria as compared with his brother in the country districts, although the latter may be often his equal, perhaps his superior in individual ability. Both as regards the early diagnosis of diphtheria and the speedy procuring of reliable antitoxin the city practitioner occupies a position of vantage. Whether the city physician always avails himself of his superior opportunities is another matter. The opportunities certainly exist, and with the development sure to take place in the efficiency of municipal laboratories, the perfection of telephone and messenger service and the establishment of stations for the delivery of antitoxin, the balance is likely to turn even more in his favor. Individual ability and special training in the use of the microscope will sometimes enable a country physician to obtain the necessary information for himself, but in accordance with the laws of specialization, such tasks in the larger towns will devolve more and more upon the expert who devotes his whole time to the work.

The same tendency is at work in other directions. The scope of municipal laboratory work is evidently broadening with the advance of scientific medicine, and new fields of activity are continually opening before it. In the diagnosis of malarial fever and typhoid fever and in the early recognition of consumption it is already rendering valuable aid to the busy city practitioner. The actual degree of usefulness of the municipal laboratory to the community is still made the shuttlecock of local political conditions, but this stage can last only so long as the city dweller continues to close his eyes to the part that might be played by the laboratory in securing and safeguarding the public health.

There are at least two particulars in which the city is still at a conspicuous disadvantage as compared with the country. These are, first, the high infant mortality, and second, the greater prevalence of various infectious diseases.

As regards the first of these, it is well known that there is a clearly established relation between infant mortality and city milk supply. The richness of milk in those very substances that render it valuable as a food is a source of danger. Not only children but microbes find milk an exceptionally nutritious food. It is not surprising that milk that is at the start carelessly collected and carelessly handled and then carried a long distance should often swarm with countless microörganisms by the time it is delivered to the consumer. In hot weather the growth of bacteria in milk is especially rapid, and much of the milk that is distributed in cities during the summer season is far advanced in the process of decomposition. The high death rate among bottle-fed infants during the summer months, and the traditional popular dread of the 'second summer' as a critical period in infant development are directly traceable to the use of stale milk. The evil is by no means

irremediable. Many enterprising milk dealers have already demonstrated the enormous improvement that can be brought about in the quality of milk by attention to simple details of collection and transportation. A high authority says of the present New York City milk supply: "There is an inexcusable lack of cleanliness in the methods of procuring milk and of care in sufficiently cooling and keeping it during its transportation. Even in the matter of sending milk to the railroad many farmers take twenty-four hours more than is necessary, keeping back one half of their milk in order to save the trouble and expense of making more than one trip each day to the station." *

In addition to the dangers and disadvantages arising from the entrance into milk of the bacteria of decomposition, there is reason to believe that the germs of disease also sometimes find their way into milk. Outbreaks of specific diseases like diphtheria and typhoid fever have been traced to infection of the milk supply, and evidence is accumulating that cases of disease from this source are more numerous than formerly supposed. There is good ground for believing that the indiscriminate use of raw milk is one of the most serious sanitary indiscretions committed by the average city dweller. The practical difficulties in the way of exercising an adequate supervision and control over the milk supply are often over-estimated by city health authorities. A large amount of time and energy is now devoted to the detection of chemical adulteration and of dilution or 'extension' of the milk, but little or nothing is attempted in regard to the vastly more important matter of protecting the general character of the supply. Much good might be accomplished by the systematic official cooperation of the health authorities with the various associations of milk dealers who are in a position to apply effective pressure to slovenly or wilfully careless producers. The milk dealers and producers as a class are rapidly awakening to the importance of scientific method, and will respond readily to any attempt made to bring the results of scientific investigation to bear upon their work. In individual instances that have come to the writer's notice, milk dealers, in their eagerness to do the right thing, are actually committing grave sanitary mistakes, and their customers receive no benefit from the dealers' endeavors, because the dealers themselves are not properly guided. Certainly the municipal authorities in some places are not performing their whole duty in this regard.

The greater general prevalence of infectious diseases among city dwellers as compared with the rural population is a second important respect in which present city conditions are strikingly disadvantageous. The more abundant opportunities for infection that are afforded, indeed made necessary, by the nature of city life and occupation can not be easily avoided, but at least their exact character can be made known

* W. H. Park, *Journal of Hygiene*, July, 1901.

and the grosser possibilities in some measure controlled. The enforcement of greater cleanliness in public buildings and conveyances, a better system for the notification and control of cases of infectious disease—a matter in which American municipalities are notoriously lax—provision of adequate hospital facilities for the reception and care of patients suffering from infectious disease are among the measures which would unquestionably reduce the city death rate from the infectious diseases. Above all, a thoroughgoing system of medical inspection of schools should be introduced. Nearly all the infectious diseases are most prevalent and most fatal among children of school age, and it would seem as if this were a highly important field in which the energies of municipal health authorities should be exercised. In some cities, as in Boston and Chicago, school inspection has been introduced with successful results, but lack of funds for the purpose has prevented a general and thorough adoption of the system. It would seem as if no reasonable expenditure should be allowed to stand in the way of this important public health measure. If money is available for safeguarding the public health in any way, it ought to be available for this purpose. If necessary, the school year should be shortened to secure the funds needed. The saving to the community of the expense of caring for cases of even the minor and less dangerous infectious diseases should constitute an effective financial argument for the general adoption of school inspection. It is perhaps significant that the growing unwillingness on the part of many of the most intelligent and public-spirited members of the community to send their children to the public schools is based on the great liability of the children to contract infections under existing conditions. The removal of this grave drawback to the public school system would in itself seem an object worth striving after.

If a small fraction of the money now expended under compulsion for over-elaborate and unnecessarily complex systems of plumbing were devoted to measures better calculated to prevent the spread of contagion, the city death rate from infectious diseases would be materially lessened and would not so largely exceed the country death rate from the same causes, as is at present the case. The campaign against infectious disease in cities should not be conducted with antiquated methods and along lines not countenanced by recent investigation, but should take advantage of the most recent scientific discoveries and above all should be carried on with a full understanding of the nature and degree of success that may reasonably be expected from the methods it is applying.

Municipal hygiene, then, to be worthy of the name should not confine itself to combating only the most dreaded or most dramatic forms of disease, but after a scientific study of the whole problem of city life should enter upon a carefully planned and systematic endeavor to re-

move or lessen some of the causes of excessive disease. There does not seem to be any sign that the desire of modern man to build himself cities and to live in them is weakening. So far ahead as any one can see, cities will continue to crowd to the edge of the stream of human life in 'a blacker, incessanter line.' Unknown forces will doubtless arise in the future which will ameliorate the conditions of city life in the way that the trolley has already done, but there will always exist certain problems peculiarly urban and created by what some curiously term the artificial conditions of city life. It should be the task of a well-conceived, far-seeing art of municipal hygiene to deal with the sanitary aspect of these problems. It does not by any means follow because some of the conditions of city life at present are distinctly inimical to human welfare that they should always remain so. And it should be recognized, furthermore, that the city possesses, within and because of its own structure, certain hygienic advantages, of which to be sure it does not always avail itself, but which in the long run will count heavily in its favor. There are already indications that these factors are becoming operative. The approximation of the urban to the rural death rate shown by the last census to have occurred in several states is not in all probability to be accounted for by a sudden shifting of the age and sex distribution of the population, but marks a real improvement in the sanitary conditions surrounding city life.

EXCESS OF URBAN OVER RURAL DEATH RATE.

Registration State.	1890.	1900.
Connecticut	3.9	.1
Massachusetts	2.7	.8
New Hampshire	1.0	1.3
New Jersey	7.9	3.3
New York	9.3	4.0
Rhode Island	1.1	.4
Vermont	3.0	.7

Since it is not true that urban life necessarily and inherently entails a higher death rate than rural life, it would seem time to dismiss the gloomy forebodings sometimes expressed that the cities are destined to become 'the graveyard of the human race,' that an inevitable physical degeneration is bound to attend life in the great centers of population, and that density of population is in itself a deplorable accompaniment of modern industrial development. Rather do the signs point to an increasing consciousness on the part of the city dweller of the hygienic advantages bestowed upon him by his position, to a deliberate and intelligent attempt on his part to master the forces that make for the excessive prevalence of disease in crowded centers, and especially to a growing realization of the necessity for a careful study and appreciation of the hygienic possibilities of his environment.

UNIVERSITY TENDENCIES IN AMERICA.*

By President DAVID STARR JORDAN,
LELAND STANFORD JUNIOR UNIVERSITY.

THE business of the university is to train men to know, to think and to do. To be will take care of itself, if the others are provided for. Wisdom is knowing what one ought to do next. Skill is knowing how to do it. Virtue is doing it. Religion is the working theory of life. It deals with the reasons why one ought to do. To all these ends the university is devoted. It does not make men. It remodels them to bring the powers they have to greater effectiveness. It brings, according to Emerson, 'every ray of varied genius to its hospitable halls,' that by their united influence 'they may strike the hearth of the youth in flame.'

Most precious of all possessions of the state is the talent of its citizens. This exists not in fact, but in possibility. What heredity carries over is not achievement, but tendency, a mode of direction of force which makes achievement possible. But to bring about results training is necessary. There can never be too many educated men, if by education we mean training along the lines of possible individual success. With birth, Emerson tells us, 'the gate of gifts is closed.' We can no longer secure something for nothing. The child's character is a mosaic of unrelated fragments, bits of heredity from a hundred sources. It is the work of education to form these into a picture. It is the art of living to range these fragments to form a consistent and effective personality.

It is the duty of the university among other things to take hold of these fragments of human possibilities and to arrange them so as to fit them for achievement. It is another duty 'to bring men to their inheritance.' This inheritance consists of the gathered experience of the past, that truth which is won through contact with realities, and with this the knowledge of the methods by which men have tested truth. Again the university has the public duty of preparing the instruments of social need.

The kings have recognized the need of universities and university men. In this need Alfred founded Oxford and Charlemagne the University of Paris. The Emperor William is quoted as saying that

* Abstract of an address before the North Central Association of Colleges and High Schools, Chicago, April 3, 1903.

'Bismarck and von Moltke were but tools in the hands of my august grandfather.' To furnish more such tools and in all the range of human activity, the University of Berlin was established.

In like manner the great historical churches and their lesser branches have founded universities each in its degree, because of the church's need of men. It has demanded trustworthy agents, expert dialecticians, great persuaders and spiritual leaders, and these have arisen in the church universities in obedience to the demand.

A like need of leaders is felt in democracy. It has a work to do greater than that of king or church and this work must be done by skilful and loyal hands. Democracy means opportunity. The greatest discovery of this most democratic twentieth century will be that 'the straight line is the shortest distance between two points.' This is a geometric definition of democracy. It trusts not to Lord this and the Earl of that. Its leaders are not chosen arbitrarily as the earliest offshoot from each link in the strain of heredity. When democracy has a man's work to do, it calls on the man who can do it. Such men it creates, and wherever they spring up they are developed in the sunshine of popular education. Democracy does not mean equality, a dead level of possession, happiness or achievement. It means equality before the law, that is the abolition of artificial distinctions made in the dark ages. It means equality of start, never equality of finish, and the most absolute equality of start makes the final equality the greater. As democracies need universities, so do universities need democracy as a means of recall to duty. Lincoln used to say that 'bath of the people' was necessary now and then for public men. This 'bath of the people' the university needs lest it substitute pedantry for wisdom, or lest it become a place for basking instead of an agency for training.

An Oxford man said not long since: 'Our men are not scholars; our scholars are not men.' Those we call scholars are bloodless pedants, finical and ineffective. Those we call men, strong, forceful, joyous, British boys, have no adequate mental training. Whether this be true of Oxford, it is often true in all universities. It is the sign that there is something wrong in practise or ideals. Scholarship should be life, and life should be guided by wisdom. The university should be a source of power, not an instrument in social advancement. Its degree should be not a badge of having done the proper thing, a device to secure the 'well-dressed feeling,' given also by 'Boston garters' and by faultless ties. The college degree is an incident in scholarship, a childish toy, so far as the real function of building up men is concerned. Prizes, honors, badges and degrees—all these matters have no necessary place in the machinery of higher education. If our universities had grown up in response to the needs of the people,

not in imitation of the colleges of England, we should never have been vexed by these things, and never have felt any need of them.

The primitive American college was built strictly on English models. Its purpose was to breed clergymen and gentlemen, and to fix on these its badge of personal culture, raising them above the common mass of men. Till within the last thirty years the traditions of the English tripos held undisputed sway. We need not go into details of the long years in which Latin, Greek and mathematics with a dash of outworn philosophy constituted higher education in America. The value of the classical course lay largely in its continuity. Whoever learned Greek, the perfect language and the noble literature, gained something with which he would never willingly part. Even the weariness of Latin grammar and the intricacies of half-understood calculus have their value in the comradery of common suffering and common hope. The weakness of the classical course lay in its lack of relation to life. It had more charms for pedants than for men, and the men of science and the men of action turned away hungry from it.

The growth of the American university came on by degrees, different steps, some broadening, some weakening, by which the tyranny of the tripos was broken, and the democracy of studies established with the democracy of men.

It was something over thirty years ago when Herbert Spencer asked this great question: 'What knowledge is of most worth?' To the schoolmen of England this came as a great shock, as it had never occurred to most of them that any knowledge had any value at all. Its function was to produce culture, which, in turn, gave social position. That there were positive values and relative values was new in their philosophy. Spencer went on to show that those subjects had most value which most strengthened and enriched life, first, those needful to the person, then those of value in professional training, then in the rearing of the family, the duty as a citizen, and finally those fitting for esthetic enjoyment. For all these, except the last, the English universities made no preparation, and for all these purposes Spencer found the highest values in science, the accumulated, tested, arranged results of human experience. Spencer's essay assumed that there was some one best course of study—the best for every man. This is one of the greatest fallacies in education. Moreover, he took little account of the teacher, perhaps assuming with some other English writers that all teachers were equally inefficient, and that the difference between one and another may be regarded as negligible.

It has been left for American experimenters in education to insist on the democracy of the intellect. The best subjects for any man to study are those best fitted for his own individual development,

those which will help make the actual most of him and his life. Democracy of intellect does not mean equality of brains, still less indifference in regard to their quality. It means simply fair play in the schedule of studies. It means the development of fit courses of study, not traditional ones, of a 'tailor-made' curriculum for each man instead of the 'hand-me-down' article, misfitting all alike.

In the time of James II., Richard Rumbold 'never could believe that God had created a few men already booted and spurred, with millions already saddled and bridled for these few to ride.' In like fashion, Andrew Dickson White could never believe that God had created a taste for the niceties of grammar or even the appreciation of noble literature, these few tastes to be met and trained while the vast body of other talents were to be left unaided and untouched, because of their traditional inferiority. In unison with President White, Ezra Cornell declared that he 'would found an institution where any person could find instruction in any study.' In like spirit the Morrill Act was framed, bringing together all rays of various genius, the engineer, and the psychologist, the student of literature and the student of exact science, 'Greek-minded' men and tillers of the soil, each to do his own work in the spirit of equality before the law. Under the same roof each one gains by mutual association. The literary student gains in seriousness and power, the engineer in refinement and appreciation. Like in character is the argument for co-education, a condition encouraged by this same Morrill Act. The men become more refined from association with noble women, the women more earnest from association with serious men. The men are more manly, the women more womanly in co-education, a condition opposed alike to rowdyism and frivolity.

In the same line we must count the influence of Mark Tappan, perhaps the first to conceive of a state university, existing solely for the good of the state, to do the work the state most needs, regardless of what other institutions may do in other states. Agassiz in these same times insisted that advanced work is better than elementary, for its better disciplinary quality. He insisted that Harvard in his day was only 'a respectable high school, where they taught the dregs of education.' Thorough training in some one line he declared was the backbone of education. It was the base line by which the real student was enabled to measure scholarship in others.

In most of our colleges the attempt to widen the course of study by introducing desirable things preceded the discovery that general courses of study prearranged had no real value. We have learned all prescribed work is bad work unless it is prescribed by the nature of the subject. The student in electrical engineering takes to mathematics, because he knows that his future success with electricity de-

pends on his mastery of mechanics and the calculus. In the same fashion, the student in medicine is willing to accept chemistry and physiology as prescribed studies. But a year in chemistry, or two years in higher mathematics, put in for the broadening of the mind or because the faculty decrees it, has no broadening effect. Work arbitrarily prescribed is always poorly done, sets low standards, and works demoralization instead of training. There can not be a greater educational farce than the required year of science in certain literary courses. The student picks out the easiest science, the easiest teacher and the easiest way to avoid work, and the whole requirement is a source of moral evil. Nothing could be farther from the scientific method than a course in science taken without the element of personal choice.

The traditional courses of study were first broken up by the addition of short courses in one thing or another, substitutes for Latin or Greek, patchwork courses without point or continuity. These substitute courses were naturally regarded as inferior, and for them very properly a new degree was devised, the degree of B.S.—Bachelor of Surfaces.

That work which is required in the nature of things is taken seriously. Serious work sets the pace, exalts the teacher, inspires the man. The individual man is important enough to justify his teachers in taking the time and the effort to plan a special course for him.

Through the movement towards the democracy of studies and constructive individualism, a new ideal is being reached in American universities, that of personal effectiveness. The ideal in England has always been that of personal culture; that of France, the achieving, through competitive examinations, of ready-made careers, the satisfaction of what Villari calls 'Impiegomania,' the craze for appointment; that of Germany, thoroughness of knowledge; that of America, the power to deal with men and conditions. Everywhere we find abundant evidence of personal effectiveness of American scholars. Not abstract thought, not life-long investigation of minute data, not separation from men of lower fortune, but the power to bring about results is the characteristic of the American scholar of to-day.

From this point of view the progress of the American university is most satisfactory, and most encouraging. The large tendencies are moving in the right direction. What shall we say of the smaller ones?

Not long ago, the subject of discussion in a thoughtful address was this: the 'Peril of the Small College.' The small college has been the guardian of higher education in the past. It is most helpful in the present and we can not afford to let it die. We understand that the large college becomes the university. Because it is rich, it at-

tempts advanced work and work in many lines. It takes its opportunity, and an opportunity which the small college can not grasp. Advanced work costs money. A wide range of subjects, taught with men, libraries and laboratories, is a costly matter, but by a variety of supply the demand is formed. The large college has many students, because it offers many opportunities. Because large opportunities bring influence and students and gifts, there is a tendency to exaggerate them. We are all prone to pretend that the facilities we offer are greater than is really the case. We are led to shout, because people are indifferent to us.

The peril of the small college is the peril of all colleges, the temptation of advertising. All boasting is self-cheapening. The peril of the small college is that in its effort to become large it shall cease to be sound. The small college can do good elementary work in several lines. It can do good advanced work in a very few. If it keeps its perspective, if it does only what it can do well, and does not pretend that bad work is good work, or that the work beyond its reach is not worth doing, it is in no danger. The small college may become either a junior college or high-grade preparatory school, sending its men elsewhere for the flower of their college education, or else it must become a small university running narrowly on a few lines, but attending to these with devotion and persistence. Either of these are honorable conditions. For the first of these the small college has a great advantage. It can come close to its students; it can 'know its men by name.' The value of a teacher decreases with the square of his distance from the pupil. The work of the freshman and sophomore years in many of our great colleges is sadly inadequate, because its means are not fitted to its ends. In very few of our large colleges does the elementary work receive the care its importance deserves.

The great college can draw the best teachers away from the small colleges. In this regard the great college has an immense advantage. It has the best teachers, the best trained, the best fitted for the work of training. But in most cases the freshman never discovers this. There is no worse teaching done under the sun than in the lower classes of some of our most famous colleges. Cheap tutors, unpractised and unpaid boys are set to lecture to classes far beyond their power to interest. We are saving our money for original research, careless of the fact that we fail to give the elementary training which makes research possible. Too often, indeed, research itself, the noblest of all university functions, is made an advertising fad. The demands of the university press have swollen the literature of science, but they have proved a doubtful aid to its quality. Get something ready. Send it out. Show that we are doing something. All this never advanced

science. It is through men born to research, trained to research, choicest product of nature and art, that science advances.

Another effect of the advertising spirit is the cheapening of salaries. The smaller the salaries, the more departments we can support. It is the spirit of advertising that leads some institutions to tolerate a type of athlete who comes as a student with none of the student's purpose. I am a firm believer in college athletics. I have done my part in them in college and out. I know that 'the color of life is red,' but the value of athletic games is lost when outside gladiators are hired to play them. No matter what the inducement, the athletic contest has no value except as the spontaneous effort of the college man. To coddle the athlete is to render him a professional. If an institution makes one rule for the ordinary student and another for the athlete it is party to a fraud. Without some such concession, half the great football teams of to-day could not exist. I would rather see football disappear and the athletic fields closed for ten years for fumigation than to see our colleges helpless in the hands of athletic professionalism, as many of them are to-day.

This is a minor matter in one sense, but it is pregnant with large dangers. Whatever the scholar does should be clean. What has the support of boards of scholars should be noble, helpful and inspiring. For the evils of college athletics, the apathy of college faculties is solely responsible. The blame falls on us: let us rise to our duty.

There is something wrong in our educational practise when a wealthy idler is allowed to take the name of student, on the sole condition that he and his grooms shall pass occasional examinations. There is no justification for the granting of degrees on cheap terms, to be used in social decoration. It is said that the chief of the great coaching trust in one of our universities earns a salary greater than was ever paid to any honest teacher. His function is to take the man who has spent the term in idleness or dissipation, and by a few hours' ingenious coaching to enable him to write a paper as good as that of a real student. The examinations thus passed are mere shams, and by the tolerance of the system the teaching force becomes responsible for it. No educational reform of the day is more important than the revival of honesty in regard to credits and examinations, such a revival of honest methods as shall make coaching trusts impossible.

The same methods which cure the aristocratic ills of idleness and cynicism are equally effective in the democratic vice of rowdyism. With high standards of work, set not at long intervals, by formal examinations, but by the daily vigilance and devotion of real teachers, all these classes of mock students disappear.

The football tramp vanishes before the work-test. The wealthy

boy takes his proper place when honest, democratic brain effort is required of him. If he is not a student, he will no longer pretend to be one and ought not to be in college. The rowdy, the mucker, the hair-cutting, gate-lifting, cane-rushing imbecile is never a real student. He is a gamin masquerading in cap and gown. The requirement of scholarship brings him to terms. If we insist that our colleges shall not pretend to educate those who can not or will not be educated, we shall have no trouble with the moral training of the students.

Above all, in the West, where education is free, we should insist that free tuition means serious work, that education means opportunity, that the student should do his part, and that the degree of the university should not be the seal of academic approbation of four years of idleness, rowdyism, profligacy or dissipation.

Higher education, properly speaking, begins when a young man goes away from home to school. The best part of higher education is the development of the instincts of the gentleman and the horizon of the scholar. To this end, self-directed industry is one of the most effective agents. As the force of example is potent in education, a college should tolerate idleness and vice neither among its students nor among its teachers.

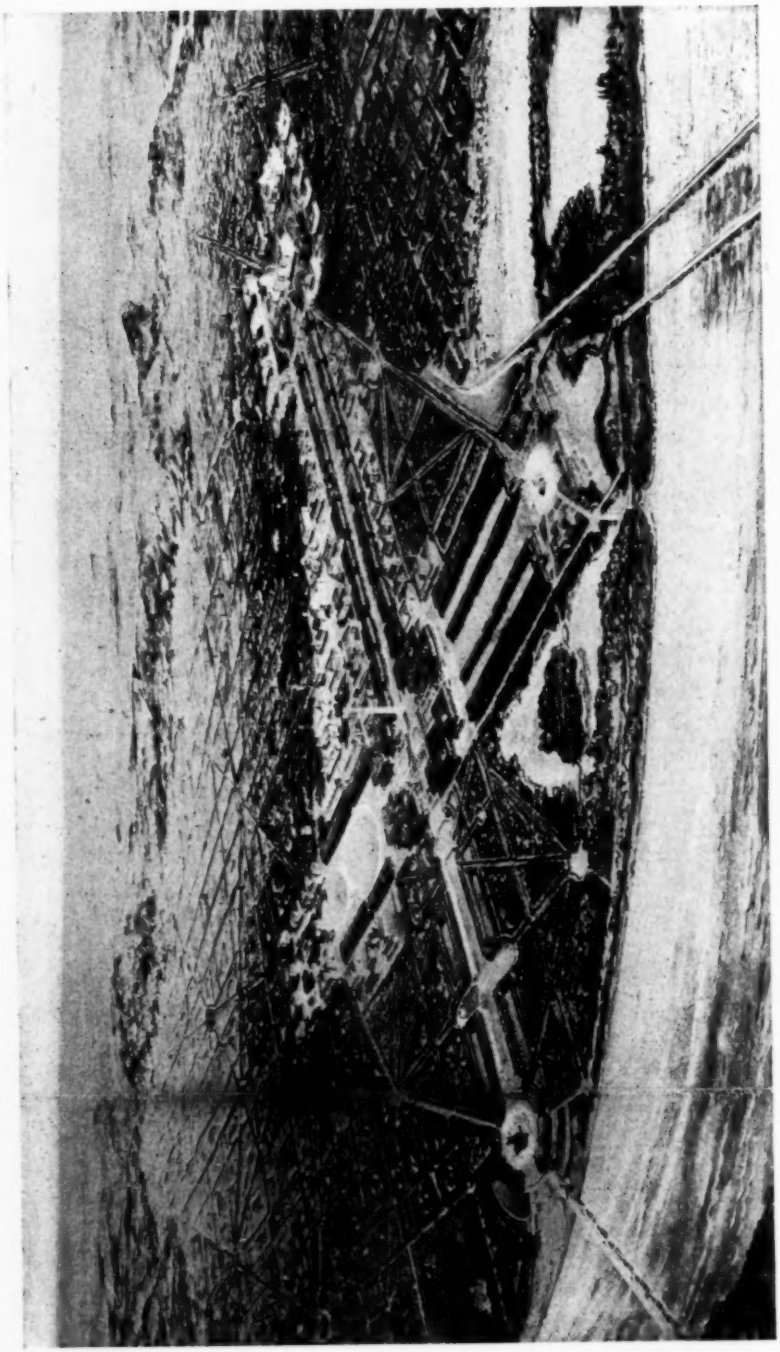
THE IMPROVEMENT OF THE CITY OF WASHINGTON.*

THE city of Washington differs from all other American cities in the fact that in its original plan parks were laid out as settings for public buildings. Even its broad avenues were arranged so as to enhance the effect of the great edifices of the nation; and the squares at the intersection of the wide thoroughfares were set apart as sites for memorials to be erected by the various states. Park, in the modern sense of a large public recreation ground, there was none; but small areas designed to beautify the connections between the various departments of government were numerous.

During the nineteenth century, however, the development of urban life and the expansion of cities has brought into prominence the need, not recognized a hundred years ago, for large parks to preserve artificially in our cities passages of rural or sylvan scenery and for spaces adapted to various special forms of recreation. Moreover, during the century that has elapsed since the foundation of the city the great space known as the Mall, which was intended to form a unified connection between the Capitol and the White House, and to furnish sites for a certain class of public buildings, has been diverted from its original purpose and cut into fragments, each portion receiving a separate and individual informal treatment, thus invading what was a single composition. Again, many reservations have passed from public into private ownership, with the result that public buildings have lost their appropriate surroundings, and new structures have been built without that landscape setting which the founders of the city relied on to give them beauty and dignity.

Happily, however, little has been lost that can not be regained at reasonable cost. Fortunately, also, during the years that have passed the Capitol has been enlarged and ennobled, and the Washington Monument, wonderful alike as an engineering feat and a work of art, has been constructed on a site that may be brought into relations with the Capitol and the White House. Doubly fortunate, moreover, is the fact that the vast and successful work of the engineers in redeeming the Potomac banks from unhealthy conditions gives opportunity for enlarging the scope of the earlier plans in a manner corresponding to

* From the report to the Senate committee on the District of Columbia of the Park Commission, consisting of Daniel H. Burnham, Chicago; Augustus St. Gaudens, New York; Charles F. McKim, New York, and Frederick Law Olmsted, Jr., Brookline.



BIRD'S-EYE VIEW OF GENERAL PLAN, FROM POINT TAKEN 4,000 FEET ABOVE ARLINGTON.

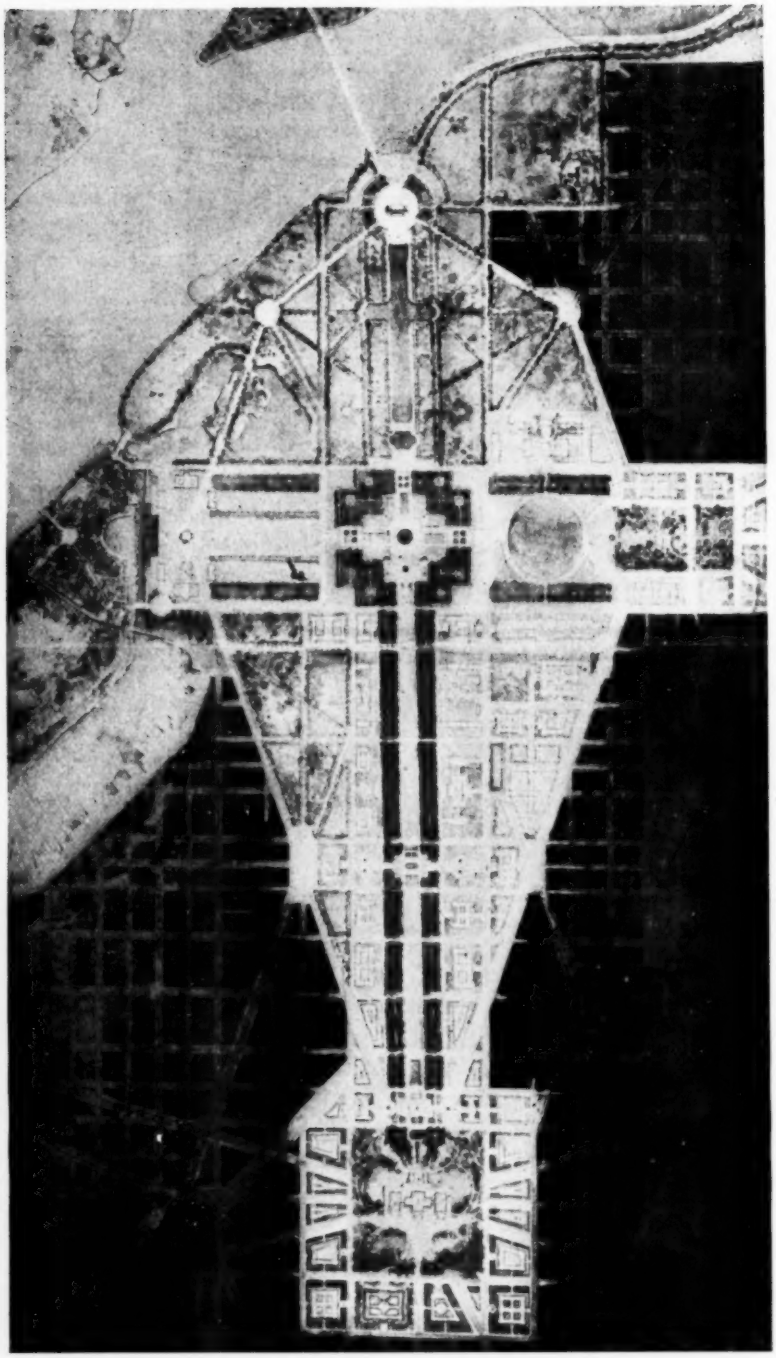
the growth of the country. At the same time the development of Potomac Park both provides for a connection between the parks on the west and those on the east, and also it may readily furnish sites for those memorials which history has shown to be worthy a place in vital relation to the great buildings and monuments erected under the personal supervision of the founders of the republic.

Now that the demand for new public buildings and memorials has reached an acute stage, there has been hesitation and embarrassment in locating them because of the uncertainty in securing appropriate sites. The commission was thus brought face to face with the problem of

MODEL OF THE MALL, SHOWING PRESENT CONDITIONS. LOOKING WEST.

devising such a plan as shall tend to restore that unity of design which was the fundamental conception of those who first laid out the city as a national capital, and of formulating definite principles for the placing of those future structures which, in order to become effective, demand both a landscape setting and a visible orderly relation one to another for their mutual support and enhancement.

To the unique problem of devising a way of return to the original plan of the city of Washington, was added the task of suggesting lines for the development of those large parks which have been obtained in recent years either by purchase or by reclamation; of advising the



GENERAL PLAN OF THE MALL SYSTEM.

acquisition of such additional spaces as are deemed necessary to create a modern park system; and of selecting for purchase and improvement suitable connections between the various park areas.

If Washington were not a nation's capital, in which the location of public buildings is of the first importance, and if the city itself were not by its very plan tied to a historic past, the problem would be less complicated. The very fact that Washington and Jefferson, L'Enfant and Ellicott, and their immediate successors, drew inspiration from the world's greatest works of landscape architecture and of civic adornment made it imperative to go back to the sources of their knowledge and taste in order to restore unity and harmony to their creations and to guide future development along appropriate lines. Indeed the more the commission studied the first plans of the Federal City, the more they became convinced that the greatest service they could perform would be done by carrying to a legitimate conclusion the comprehensive, intelligent, and yet simple and straightforward scheme devised by L'Enfant under the direction of Washington and Jefferson.

PART OF L'ENFANT MAP OF WASHINGTON (1791).

L'Enfant's plan shows that he was familiar with the work of Lenôtre, whose examples of landscape architecture, not only in France but also in Italy and England, are still the admiration of the world. We know, also, that L'Enfant had the advantage of those maps of foreign cities, 'drawn on a large and accurate scale,' which Jefferson gathered during his public service abroad, and we learn from Jefferson's letters how he adjured L'Enfant not to depart from classical models, but to follow those examples which the world had agreed to admire. In order to re-study the same models and to take note of the great civic works of Europe, the commission spent five weeks of the summer of 1901 in foreign travel, visiting London, Paris, Rome, Venice, Vienna, Budapest, Frankfort and Berlin. Among the many problems with which the commission is called upon to deal, there is not one which has not been dealt with in some one of the cities mentioned, and

by way either of example or of warning the lessons of the past have been brought to bear upon the present work.

On beginning work the commission was confronted by the fact that while from the first of October till about the middle of May the climatic conditions of Washington are most salubrious, during the remaining four and a half months the city is subject to extended periods of intense heat, during which all public business is conducted at an undue expenditure of physical force. Every second year congress is in session usually until about the middle of July; and not infrequently it happens that, by reason of prolonged or special sessions, during the hottest portion of the summer the city is filled with the persons whose business makes necessary a more or less prolonged stay

VIEW SHOWING THE PROPOSED TREATMENT OF UNION SQUARE, AT THE HEAD OF THE MALL.

in Washington. Of course nothing can be done to change weather conditions, but very much can be accomplished to mitigate the physical strain caused by summer heat. Singularly enough, up to the present time the abundant facilities which nature affords for healthful and pleasant recreation during heated terms have been neglected, and in this respect Washington is far behind other cities whose climatic conditions demand much less, and whose opportunities also are less favorable.

In Rome throughout the centuries it has been the pride of emperor and of pope to build fountains to promote health and give pleasure. Mile after mile of aqueduct has been constructed to gather the water even from remote hills, and bring great living streams into every quarter of the city; so that from the moment of entering the Eternal City until the time of departure the visitor is scarcely out of sight of beautiful jets of water, now flung upward in great columns to add life and

dignity even to St. Peter's, or again gushing in the form of cascades from some great work of architect or sculptor, or still again dripping refreshingly over the brim of a beautiful basin that was old when the Christian era began. The Forum is in ruins, basilicas and baths have been transformed into churches, palaces have been turned into museums; but the fountains of Rome are eternal.

If all the fountains of Washington, instead of being left lifeless and inert as they are during a greater portion of the time, should be set playing at their full capacity, they would not use the amount of water that bursts from the world-famous fountain of Trevi or splashes on the stones of the piazza of St. Peter's. At the Château de Vaux-

VIEW IN MONUMENT GARDEN, MAIN AXIS, SHOWING PROPOSED TREATMENT OF APPROACHES AND TERRACES, FORMING A SETTING FOR THE WASHINGTON MONUMENT.

le-Vicomte, near Paris, the great landscape architect Lenôtre built cascades, canals, and fountains, using one twelfth of the daily water-supply of the District of Columbia. The fountains at Versailles are one of the most attractive spectacles enjoyed by the people of France.

The original plans of Washington show the high appreciation L'Enfant had for all forms of water decoration; and when the heats of a Washington summer are taken into consideration, further argument is unnecessary to prove that the first and greatest step in the matter of beautifying the District of Columbia is such an increase in the water supply as will make possible the copious and even lavish use of water in fountains.

The location of public buildings has received the very careful consideration of the commission. In general terms their conclusions are:

1. That only public buildings should face the grounds of the Capitol.

2. That new department buildings may well be located so as to face Lafayette square.

VIEW SHOWING THE PROPOSED DEVELOPMENT OF THE LINCOLN MEMORIAL SITE, SEEN FROM THE CANAL.

PROPOSED DEVELOPMENT OF LINCOLN MEMORIAL SITE, SEEN FROM RIVERSIDE DRIVE.

3. Buildings of a semi-public character may be located south of the present Corcoran Art Gallery, fronting on the White Lot and extending to the park limits.

4. That the northern side of the Mall may properly be used by museum and other buildings containing collections in which the public generally is interested, but not by department buildings.

5. That the space between Pennsylvania avenue and the Mall should be occupied by the District building, the Hall of Records, a modern market, an armory for the District militia, and structures of like character.

The city of Washington, during the century since its foundation, has been developed in the main according to the plan made in 1791 by Major Peter Charles L'Enfant and approved by President Washington. That plan the commission has aimed to restore, develop and supplement.

The 'Congress house' and the 'President's palace,' as he termed them, were the cardinal features of L'Enfant's plan; and these edifices he connected 'by a grand avenue four hundred feet in breadth, and

ANACOSTIA MARSHES FROM BENNING BRIDGE, SHOWING MALARIAL FLATS TO BE EXCAVATED

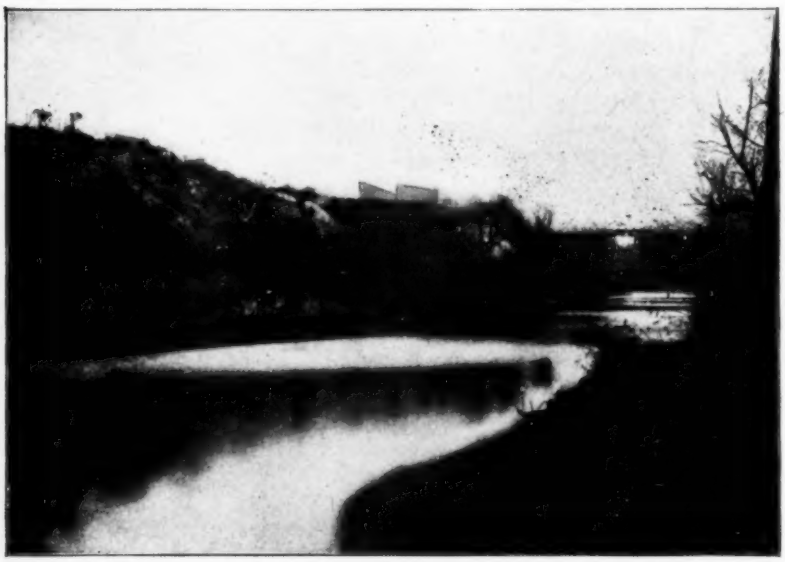
about a mile in length, bordered by gardens, ending in a slope from the houses on each side.' At the point of intersection of two lines, one drawn through the center of the Capitol, the other drawn through the center of the White House, L'Enfant fixed the site of an equestrian statue of General Washington, one of the numerous statues voted by the Continental Congress but never erected.

When, in 1848, the people began to build the Washington Monument, the engineers despaired of securing on the proper site a foundation sufficient for so great a structure; and consequently the Monument was located out of all relations with the buildings which it was intended to tie together in a single composition. To create these rela-

tions as originally planned was one of the chief problems of the commission.

Again, the reclamation of the Potomac flats, prosecuted since 1882, has added to the monument grounds an area about one mile in length from east to west; so that where L'Enfant dealt with a composition one and a half miles in length, the commission is called upon to deal with an area two and a half miles long, with a maximum breadth of about one mile.

By the inclusion of the space between Pennsylvania and New York avenues on the north, and Maryland avenue and the Potomac River on the south, the new composition becomes a symmetrical, polygonal or



ROCK CREEK, SHOWING POSSIBILITY OF SECLUSION FROM DISAGREEABLE SURROUNDINGS.

kite-shaped figure bisected from east to west by the axis of the Capitol and from north to south by the White House axis. Regarding the Monument as the center, the Capitol as the base, and the White House as the extremity of one arm of a Latin cross, we have at the head of the composition on the banks of the Potomac a memorial site of the greatest possible dignity, with a second and only less commanding site at the extremity of the second arm.

So extensive a composition, and one containing such important elements, does not exist elsewhere; and it is essential that the plan for its treatment shall combine simplicity with dignity.

CHANGES IN THE AGE OF COLLEGE GRADUATION.

By W. SCOTT THOMAS,
TEACHERS COLLEGE, COLUMBIA UNIVERSITY.

THE belief seems to have become general that the American boy of to-day takes his first collegiate degree—A.B. or its equivalent—a good deal older than his father took his, and a great deal older than his grandfather. The present study was undertaken with a view to determining from actual records the measure and rate, if real, of this increase. The plates and tables that are presented herewith tell, in the main, their own story; my task will be little more than the making of a running commentary upon these.

The calculations are based upon nearly twenty thousand cases, and include the graduates of eleven colleges, representing all parts of the country except the extreme west. If undue weight seems to be given to the New England colleges, my excuse is twofold: first, the proportion of colleges that date back fifty years or more is much larger in New England than elsewhere; secondly, I have used all the published material I have been able to find, in the shape of alumni catalogues which give the date of birth of graduates. These have, moreover, been largely supplemented by private information very kindly furnished by the officers of colleges whose general catalogues do not come down to the year 1900.

The results are given in decade periods for the double reason that shorter periods are unwieldy, becoming too numerous, and because the longer period is more reliable. Two- or three-year periods often show what seems a very decided trend in a given direction; but this is in all cases decidedly modified if not entirely obliterated by the addition of the remaining years of the ten. The results thus win stability and evenness.

Before beginning the discussion of the tables and plates, one further word of explanation may be given. It will be noted that in Table I. and elsewhere the median age is used rather than the average age. The reasons for using the median age—the point above which and below which, respectively, one half of the students in each decade graduate—are evident. In the first place, the labor of finding the exact arithmetical average of the age of graduation of 20,000 students would be enormous; and when found it would not give us what we wish, viz., the age at which the students, or a definite percentage of them, actually

do graduate. It is evident that a few students graduating in a class above forty years of age—by no means an unheard-of state of affairs—would unfairly raise the average age of that class, since it is manifestly impossible to graduate twenty years below the normal age. Again, a class, or series of classes, may graduate a considerable number of its members below twenty, while a still larger number graduates above twenty-four or twenty-five. The curve of distribution of the ages of graduation will then resemble the letter M. Manifestly, in such a case, which occurs several times, the arithmetical average tells us nothing of value. Finally, the median age gives us the exact information that one half the students in question graduated at or above the given age, and the other half at or below it. The curves of distribution, moreover, given in the plates for all graduates and all colleges for the years 1850–59 and 1890–99, show exactly what percentage graduated at each age.

TABLE I.

MEDIAN AGES OF GRADUATION BY DECADES.

	Dartmouth.		Middlebury.		Bowdoin.		U. of Ver.		Adelbert.	
	Age.	No.	Age.	No.	Age.	No.	Age.	No.	Age.	No.
1770–79	23–0	78								
1780–89	23–1	150								
1790–99	23–2	336								
1800–09	22–6	323	22–10	76						
1810–19	22–9	330	23–1	194	20–4	106				
1820–29	23–1	328	23–0	187	20–8	258	22–4	59		
1830–39	22–5	384	23–4	242	21–7	289	22–7	80	23–0	41
1840–49	23–1	586	22–8	109	21–9	356	22–0	184	23–2	125
1850–59	23–8	558	23–3	121	22–1	335	22–4	168	23–0	98
1860–69	23–1	491	23–5	132	22–10	348	22–6	91	22–10	160
1870–79	22–10	593	23–4	111	22–5	321	22–6	98	22–9	217
1880–89	22–10	527	22–11	86	22–8	303	22–8	108	23–0	251
1890–99	22–9	678	23–2	125	22–7	481	22–9	215	22–9	156

We now come to a consideration of Table I.* The most obvious and surprising thing that strikes us at first sight is the fact that our

* In Table I., decade '1770–79,' equals Dartmouth 1771–79; decade '1800–09,' equals Middlebury 1803–09; decade '1830–39,' equals Alabama 1832–39, New York University 1833–39, Oberlin 1837–39, Wesleyan 1833–39; decade '1850–59,' equals in Syracuse 1852–59. In each case the corrected year marks the date of the first graduating class. In decade '1890–99' Adelbert includes only the years 1890–95; New York University, 1890–94; Syracuse, 1890–98. In Alabama University there were no graduates for the years 1866–71 inclusive. During several of these years the university was closed.

The data for the decade '1900– ' are as follows: Dartmouth, Oberlin, DePauw, each, class of 1900 only; Wesleyan, Alabama and Vermont, classes of 1900–01; Bowdoin, 1900–02. The whole number of cases in this 'decade' is 572.

In reference to the degrees included in the investigation, I have attempted to use only A.B., Ph.B. and B.S. In a few instances the last named degree

assumed great increase in the age of graduation, taken generally and so far as our material reaches, is absolutely non-existent.

The median age of graduation in Dartmouth, for instance, has in one hundred and thirty years fallen three months; in one hundred years the median for Middlebury has risen four months. But note that in 1830–39 the median for Middlebury was two months higher than now. In the case of Bowdoin, there has been a steady rise to a little over two years, which, however, reached its maximum in the decade beginning in 1860, and has since been falling. In seventy years, the University of Vermont median age has risen but two months; while in the same period that of Adelbert College has fallen three months. Again, we may compare the New York University with Oberlin College. While the age at the former has in sixty years risen one year and five months, in the latter it has fallen one year and seven months. It may be noted in passing that the number of graduates in the given

TABLE I.

MEDIAN AGES OF GRADUATION BY DECADES.

U. of Ala.		N. Y. Uni.		Wesleyan.		Oberlin.		De Pauw.		Syracuse.	
Age.	No.	Age.	No.	Age.	No.	Age.	No.	Age.	No.	Age.	No.
20–4	57	20–2	73	23–0	107	24–11	34				
20–3	126	20–3	147	23–3	231	25–6	122	21–7	63		
20–9	173	20–7	102	23–4	231	25–2	120	22–9	89	23–11	28
20–0	48	20–8	128	24–0	260	24–0	176	23–2	115	24–0	29
20–3	66	21–6	141	23–8	325	24–3	270	23–1	230	24–6	138
20–0	209	21–1	154	23–3	323	24–3	267	23–2	317	23–9	224
20–2	270	21–8	115	23–6	456	23–11	403	23–9	371	23–11	264

seems to be used as a semi-professional degree, implying for instance, that the student has taken an engineering, or some such course not purely 'cultural.' It seemed impossible to shut out entirely cases of the semi-professional degrees. The number of them is, however, too small to materially influence the results. In Dartmouth College the graduates of the Chandeler Scientific School are not included in the calculations, for the reasons above given. The justice of the exclusions above referred to is evident at once; for the examination is an attempt to show the changes that have come about in the college course as formerly understood. That is, when it did not include the study of a profession within itself, as several of the present courses do.

Only young men have been considered in my inquiry. It is interesting, however, to note that if young women had been included in the investigation, the averages and medians would have, in almost every case, been materially reduced. In other words, the young woman is either more highly selected as a student, or she meets with fewer hindrances external to her work while going through high school and college. At any rate, whatever the cause or causes may be, the young woman graduates are, as a rule, younger than the young men in the same college. This subject is worthy of a separate inquiry.

time is in Oberlin about double that in the New York University. Finally, we may call attention to the fact that in the University of Alabama and in Syracuse University, the age of graduation has remained practically unchanged, with a slight tendency to decrease.

So much for the general aspects of Table I. It will be of some interest to consider somewhat closely the changes that have come within the last two generations of college graduates, or since 1850. At this period all the colleges in our list are available for comparison; and it is since the beginning of this period that practically all the modern development of the American college has taken place. What happened before 1850, while it may be interesting, can not have the importance for us now that the changes of the past fifty years have.

At the outset, we note that of the eleven colleges in the table, the median age for one only remains quite unchanged—Syracuse. The following show increases, in months: Bowdoin, 6; Vermont, 5; New York University, 13; Wesleyan, 2; DePauw, 12; total, 38. The following show decreases, thus: Dartmouth, 11; Adelbert, 3; Alabama, 7; Oberlin, 15; Middlebury, 1; total, 37.

TABLE II.

AVERAGE OF MEDIAN AGE OF GRADUATION FOR PAST FIFTY YEARS.

	1850-59	1860-69	1870-79	1880-89	1890-99
Dartmouth	23-8	23-1	22-10	22-10	22-9
Middlebury	23-3	23-5	23-4	22-11	23-2
Bowdoin	22-1	22-10	22-5	22-8	22-7
Univ. of Vt.	22-4	22-6	22-6	22-8	22-9
Adelbert	23-0	22-10	22-9	23-0	22-9
Univ. of Ala.	20-9	20-0	20-3	20-0	20-2
N. Y. Univ.	20-7	20-8	21-6	21-1	21-8
Wesleyan	23-4	24-0	23-8	23-3	23-6
Oberlin	25-2	24-0	24-3	24-3	23-11
DePauw	22-9	23-2	23-1	23-2	23-9
Syracuse	23-11	24-0	24-6	23-9	23-11
Av. of Totals	22-9.6	22-9.3	22-9.9	22-8.3	22-7.5

The net result of the changes that have come in the age of graduation in these fifty years is more clearly presented to the eye by Table II. Here is presented a view of the medians for all the eleven colleges, wherein each college is given an equal weight, regardless of whether it be a large or a small college. By this method then is avoided the overweighting which a large college, like Dartmouth or Bowdoin, would otherwise exert on the results. The results show that in only one decade is the average of medians as high as that of 1850–59. Moreover, the last two decades show a slight decreasing tendency, making a net reduction in fifty years of two months for all the colleges.

Thus far we have dealt with the median age of graduation as distinct from the average age, and reasons have been adduced to show why the

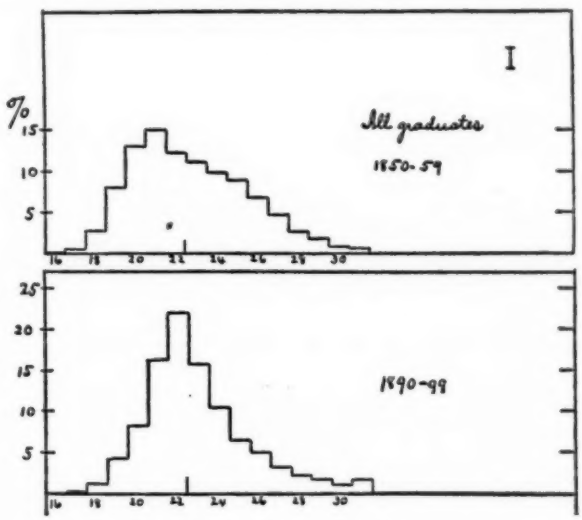
former is preferable to the latter as the measure in our present study. Inasmuch, however, as the arithmetical mean is the one in most common use, and further, as some may still feel that it, if investigated, would show the rise that has been supposed to exist, we will consider the data and results that Table III. shows. In this table are shown

TABLE III.

AVERAGE AGE OF GRADUATION FOR THE PAST FIFTY YEARS.

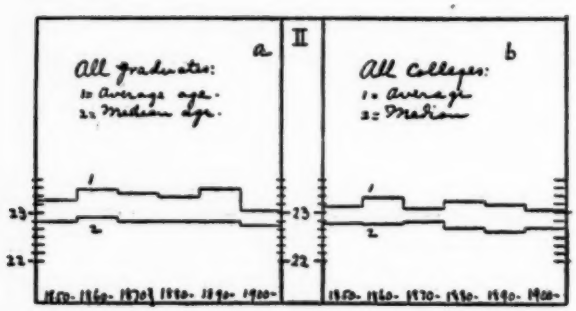
	1850-59	1860-69	1870-79	1880-89	1890-99	Cases.
Dartmouth	23-9.4	23-6.7	23-4.9	23-1.3	23-2.7	5362
Middlebury	23-8.1	23-6.5	23-5.8	23-6.5	23-8.1	1386
Bowdoin	22-6.4	22-11.7	23-0.0	23-1.6	23-2.4	2797
Vermont	22-11.5	23-3.3	22-8.6	23-3.4	23-0.2	1003
Adelbert	23-9.6	23-7.2	23-2.4	23-2.4	22-10.8	1048
U. of Ala.	21-0.0	20-1.8	20-2.4	20-3.6	20-6.0	949
N. Y. U.	21-1.6	21-2.3	20-8.4	21-7.5	21-10.8	860
Wesleyan	23-10.8	24-3.3	24-2.8	23-10.2	23-6.1	1933
Oberlin	25-0.7	24-7.5	24-5.3	24-8.7	24-3.9	1392
DePauw	22-2.4	23-8.4	23-8.4	23-9.1	23-10.3	1185
Syracuse	24-1.6	24-5.0	24-7.7	24-8.6	24-7.5	751
Av. of Totals.	23-1.3	23-3.4	23-0.8	23-2.3	23-1.9	

the arithmetical averages of each college by decades, supposing that the students graduating at any given year of age, say 22, are about equally distributed throughout the months of the year, thus giving an average for the given year of, say 22.5 years. With small numbers,



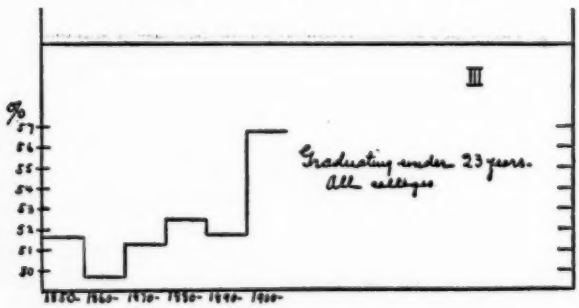
this assumption is not without its liability to error; but with numbers so large as we have, the errors are found by actual trial practically to negative each other; so that we can rely upon the results as being, for all practical purposes, and in the main, substantially correct.

The first striking thing to be observed in Table III. is the fact that the average age is a few months higher than the median throughout in the totals of all colleges. In the past fifty years, the average age of graduation has remained quite unchanged, while in the past forty years, the average has fallen one and a half months. This difference



is, however, probably too small to be in itself significant, so that we may conclude that there is neither any actual change in the average, nor any definite tendency observable towards rising or falling.

In the above discussion of averages, each college has been given the same weight as every other. Now, we may look at the same matter from another point of view. We may bunch all the graduates, as though

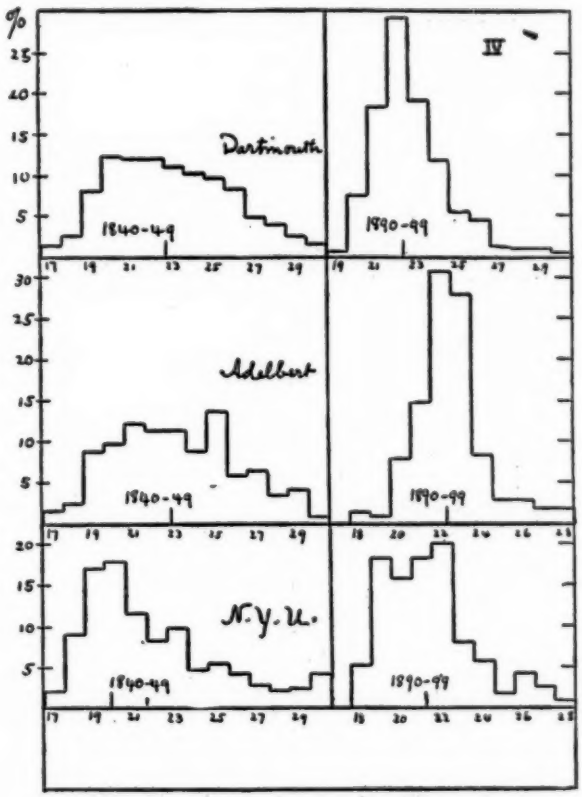


they were all students of one great college; and, still assuming that they will be about equally distributed through the months of any given year—an assumption which by the now very much larger numbers is made doubly secure—we may take the average for the five decades since 1850. By this method we obtain the following results:

	1850-59.	1860-69.	1870-79.	1880-89.	1890-99.	1900- .
	Yr. M.	Yr. M.	Yr. M.	Yr. M.	Yr. M.	Yr. M.
Av.....	23 3.0	23 5.4	23 4.8	23 3.9	23 6.1	23 0.5

Even here, where every concession possible is allowed to the weighting of the averages by the few colleges which in the last decade have relatively much larger numbers, together with their consistently

higher average age of graduation than in the earlier decades, we still find no change of any significance. At the very best, or worst, the change in fifty years past has been only three months. While now, if we may use for the sake of further illustration the available data of the colleges for the decade beginning 1900, we find on an average three months less than that of 1850–59. The colleges included here are those seven which furnished for the decade 1890–99 over 81 per cent. of all graduates, and include all the colleges except New York University, Adelbert College, Middlebury College and Syracuse Uni-

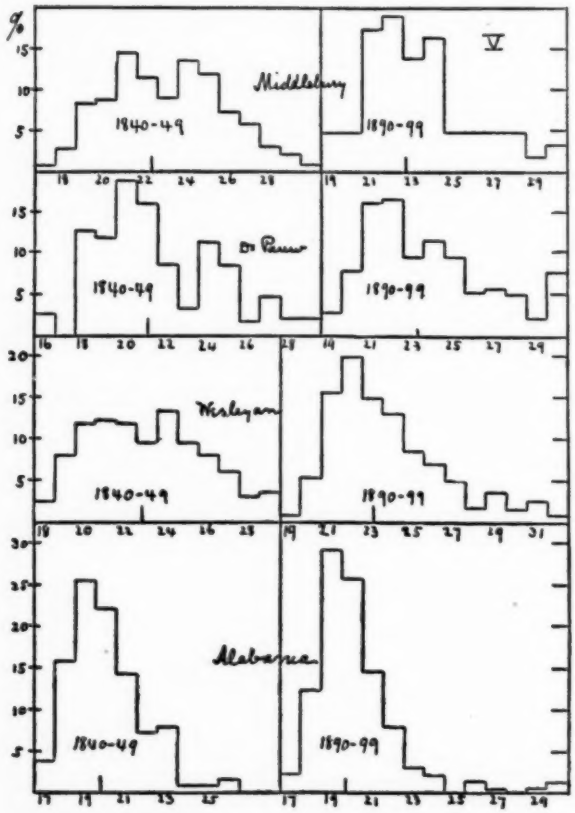


versity. It will be noted that all the largest colleges are included, and that of those omitted two are above and two below the average in the decade 1890–99.

We may now turn from the consideration of the tables to an examination of the plates. Plate I. shows the percentage of students actually graduating at each age—16 years to 31 years—in which last category are bunched for convenience all graduates of the age of 31 years or over—for the two decades 1850–59 and 1890–99, respectively. The upright line on the base in the twenty-second year marks the actual

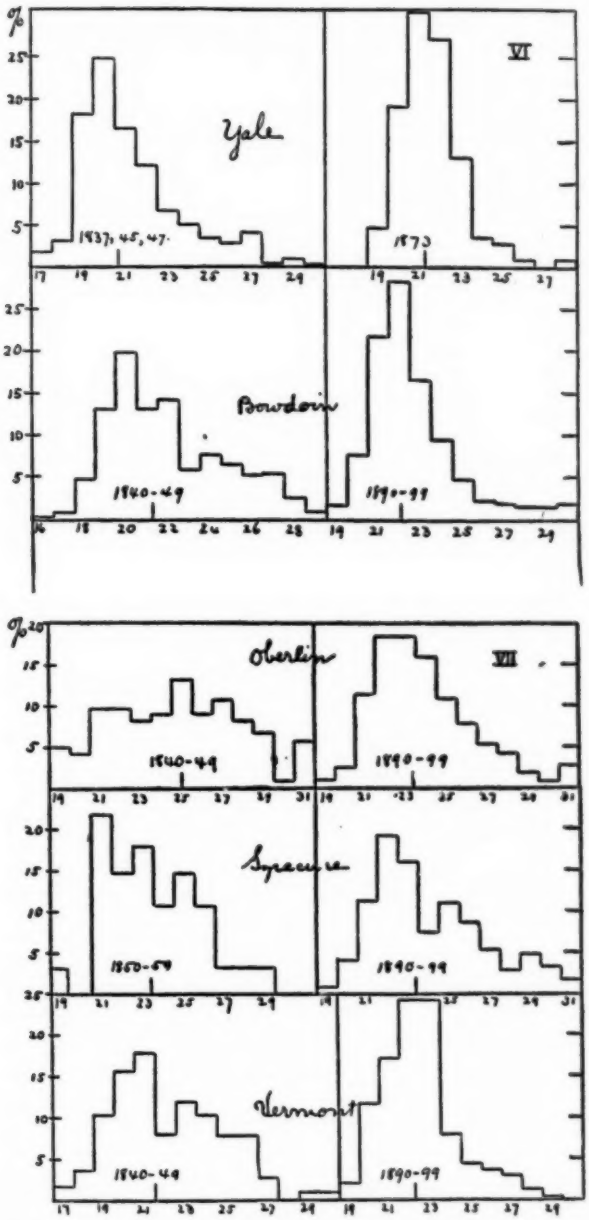
median age of graduation of all students for the decade. It will be noticed that its position remains absolutely unchanged. Perhaps the most noticeable exhibition presented by this plate is the pushing of the great bulk of graduates in the last decade into the comparatively narrow compass of the years 20–24, and the consequent great reduction of the numbers graduating above or below these limits as compared with the earlier decade.

One further observation is worth making: At first sight it appears that the mode—the year in which the largest number graduates—is in



the first decade, the twenty-first year; while in the second decade this has been pushed up, and is now the twenty-second. In this there are two matters of significance. First, while the mode in the first decade is 21, the percentage here is still less than it is in the same year in the next decade, where the mode appears as 22; secondly, the reduction of the percentages in the years below the twenty-second in the second decade is largely due to the fact that in the first decade two or three colleges which have a high median age of graduation have in this decade

very few students, while in the last decade they have a relatively very much higher number of graduates, thus acquiring an undue influence in the second decade, and failing to exert this influence in the first



decade. This fact, which does not come out in this plate, becomes much clearer if we take decade 1860–69 for comparison with decade 1890–99.

Plates IV., V., VI. and VII. present the evolution of the individual colleges during the last five or six decades in the matter of concentration of the body of graduates into a few years. We may in a measure take the degree of this concentration as an indication of the homogeneity of the student body, and of the organization of the educational machinery that prepares the students for college. It will be noted that while there is the greatest difference in the degree to which the condensation has gone on in different colleges, there is, nevertheless, a distinct and uniform tendency towards this concentration, which must in every case be set down as a distinct advantage to the college. The ideal types may be said to be very nearly approximated by such curves as those of Yale, Plate VI., Adelbert and Dartmouth, Plate IV., and Alabama, Plate V. Such a curve as that of Dartmouth, which we may take as the type which all the other colleges more or less closely resemble, shows most clearly that the college has changed in sixty years from a place to which a young man might go for study at any age, to a place to which young men go as a matter of business, so to speak, and at a definite period of their life. In other words, the going to college has become a matter of social organization, with its very definite place in the life of the youth. The intermediate decades, which lack of space prevents our showing, present curves which show how gradually this change has come about. It seems, further, a safe conclusion to say that all the colleges that have not yet reached the high degree of concentration which some show are, nevertheless, distinctly destined to come to it, unless some unseen force changes their direction of development.

It should be noted, in passing, that an anomaly, such as the curve of Syracuse for 1850–59, is due to the small number of cases. There were but twenty-nine graduates in this decade.

Plate II. presents in graphic form the same facts that have been given in the tables. Division 'a' shows in the upper line, marked '1,' the average age of all graduates as presented in Table III., 'Average of Totals,' plus the data for decade 1900, so far as available, also referred to above. The second line, marked '2,' gives the actual median age of all graduates considered as students of one college. It will be noted that, while the median has remained practically uniform throughout, the average has varied, but with no marked tendency either up or down.

Plate II. 'b' presents the same facts as 'a,' except the units of comparison are now colleges instead of individual students. While, as would be expected from the small number of cases, the fluctuations are greater than in the 'a' division, the same absence of pronounced trend in either direction is easily observable.

There is one tendency in American education which it seems we may accept as established beyond cavil, viz., that for the future, the public high school will take the place of the old academy, as the institution in which the average boy will receive his training antecedent to entering college. In the days of our grandfathers, the prospective college student received his preparation for college either under the private instruction of his pastor, or in one of the academies of the time. In either case, the body of college-going boys was a highly selected one—a class who had both the tradition of the scholarly life and, to no small extent, the taste and opportunities to follow this tradition. Then, even more than now, the college turned out men whose future work was to be the ministry, law or medicine.

With the advent of the public high school and the growing tendency of colleges to accept its graduates for entrance to college courses, we should expect to find two or three changes in particular becoming manifest: First, we should expect to find the college-going students less selected along the lines of intellectual aptitudes and scholarly traditions; secondly, we should expect a greater scope of life employment among the college graduates; and thirdly, we should anticipate a natural advance in the age at which boys would go to college as a result of the above-named circumstances, with all that they imply. Now, our public school system is, for the most part, so constructed that the normal age for a boy to finish his high school course is in his nineteenth year, making his age of graduation from college between 22 years and 22 years, 11 months, inclusive.

From this point of view, it becomes important to examine our data with a view to finding out in how far these influences which would be expected to raise the age of graduation from college have been active over other conditions which have negatived them, or *vice versa*. Plate III. shows the percentage of students that actually graduated in all colleges under the age of 23 years, since 1850—the date at which the data for all our colleges become available. Comment is hardly necessary here. With the exception of decade 1860–69, which evidently shows the effects of the civil war, the trend has been unmistakably upwards. Even if we throw out the figures for 1900—which represent, as explained above, all the available data from the colleges that in 1890–99 furnished over 81 per cent. of all graduates—the trend is still unmistakably upwards.

Concerning the influences that have been instrumental in causing the marked rise in the median or average age of graduation in certain colleges in our list, it is not possible to speak with certainty for all. In the case of one or two, such as New York University and Bowdoin College, it would seem that the rise is due to an increase in the requirements for admission. In the case of certain other, pronouncedly

denominational institutions, as DePauw and Syracuse, there is one element separable from perhaps others that may be surmised, which has played an important rôle. This is found in the decidedly high average or median age of those young men who go into the ministry. The following shows the conditions in the two institutions just named:

	DePauw University (1). Median of non-ministers.		DePauw University (2). Median of ministers.		Syracuse University (1). Median of ministers.		Syracuse University (2). Median of ministers.		Per cent. of ministers.	
	(1)		(2)		(1)		(2)		(1)	(2)
1850–59	22	1	23	8	25	5	25	6	27.2	27.6
1860–69	23	1	23	3	23	3	24	6	22.8	41.6
1870–79	22	7	23	11	25	6	25	9	25.2	28.5
1880–89	22	11	23	3	25	3	25	6	25.4	31.7
1890–99	22	9	23	2	26	9	26	7	22.2	30.7

It thus appears that our medians for these two colleges as shown in Table II. would, with this element of disturbance removed, give quite different results. Thus the median of the last decade for DePauw would be lowered by just twelve months; while that of Syracuse for the same decade, instead of remaining the same as that of fifty years before, would be lowered by nine months.

While I have not been able to work over the data for the other denominational colleges completely enough to give the results here, there are nevertheless many indications that a similar state of affairs prevails, though probably in different degree.

In conclusion, we may sum up our findings as follows: The increase in age of graduation from college in general has been tremendously exaggerated. It exists only for certain institutions; while others show a corresponding decrease.

The normal age of graduation, as our school system is constituted, is below twenty-three years and above twenty-two; our results show that more students graduate now within those limits than ever before; that the gradually organizing secondary education tends to make this percentage increasingly larger. (Nearly 85 per cent. of all graduates of the Johns Hopkins University in the twenty years since its founding to 1899 have been within these limits.)

If entrance into professional life is later than formerly, the cause must be sought elsewhere than in the college and preparatory school.

Whereas it was once *possible* for a boy to graduate from college at sixteen or even younger, though very few really did so, this is true no longer. But the young man now, as a consequence, leaves college with very much higher academic attainments, and but little if any older than was his father, or even his grandfather.

All colleges show, in different degrees, an increasing diminution of range in age of graduation. This shows that the secondary education is becoming better organized.

If now, the age of graduation which we have shown to be the prevailing one, viz., 22.5 years, be deemed still too old, three means of reducing this would seem to be possible: First, cut off one year from the college course, without lowering the entrance requirements; secondly, in view of the far greater efficiency of the secondary school, reduce the entrance requirements to college and, retaining the four years' course, permit the boy to enter college, say, a year younger; thirdly, drop one year from the college course, increase the length of the actual weeks of residence and instruction to thirty-eight or forty, and endeavor to disabuse the mind of the average collegian of the belief that college is a place to dawdle and loaf four years for the sake of a degree that he does not earn, but which he generally gets just the same. The college would then have a serious opportunity to prove its right to existence, and if it succeeded, the present dilettantism of college life would tend to disappear.

One further suggestion we may venture to make. Every boy that has the native capacity to do college work should be put into the high school in the fall after he is fourteen years old, regardless of whether he has done all the prescribed grammar school work or not. If he can not then get ready for college by eighteen, don't let him go to college. He is not cut out for the strenuous intellectual life.

EDUCATION NOT THE CAUSE OF RACE DECLINE.

By GEORGE J. ENGELMANN, M.D.,

BOSTON.

YALE graduate families have been growing steadily smaller, says Mr. Clarence Deming in an interesting review (*Yale Alumni Weekly,* March 4, 1903) based upon class returns which show a gradually decreasing fecundity from 1810 to 1880: this statement together with the small size of the Harvard family as revealed by the report of President Eliot, has justly directed attention to the apparently sad family condition prevalent among college graduates, or, as it has been expressed, among 'the highly educated portion of our population'; and it is generally assumed that this small family size pertains mainly to the highly educated, that conditions are better among the—let us say—*less* highly educated. It has been inferred that college graduates' families stand alone in not reproducing themselves and 'not adding to the increase of the population,' and that other portions of the population do so reproduce and add to the increase. Accepting this, it naturally follows that education, which has caused the mischief, must be suitably regulated. One suggestion is to shorten the term of study. But are the premises correct?

Speculation has been rife, and the small size of the graduate family is discussed far and wide without ever a thought as to what the conditions among the great mass of our native population may be, and yet it would be well to establish the facts in the case, and to determine the existence of an exceptionally low fecundity among college graduate families before deciding on cause and cure.

True, the average graduate family does not reproduce itself, but no more does that of any other group of our native American population, and the surviving family, the net family of the college graduate is not smaller, but actually larger than that of his less highly educated brother. This points to an unusually low rate of reproduction for the entire native-born element of our population; in fact the conditions now existing among the American people are worse than those found in any other country. They are those of a decadent race, those of Greece and Rome in the period of decline; and again and again, within the past few years, have I urged that the attention of thinking men be seriously given to a consideration of the alarming status attained.

To present this properly, and demonstrate the part taken by each group in the movements of population, it is essential to consider class reproduction; not alone fecundity and size of family, but marriage rate as well must be taken into account. In both the status of the college graduate as a class is most creditable, and at variance with all that has been assumed, though conditions differ greatly in individual institutions.

The marriage rate is surprisingly high for the highly educated, or, to be precise, for 4,408 college graduates, even if the 88.7 per cent. of Brown '72 and the 87 per cent. of the Bowdoin classes of 1875 and '77 is above the average, which is 79.4 per cent. for 16 Yale, Brown, Bowdoin and Princeton classes, and 75.4 per cent. if we include the 9 Harvard classes '72–'80 with their low marriage rate of 71.4 per cent.

My investigations show that the college graduate, the academic graduate (conditions differ for scientific graduates), marries 7–7½ years after leaving college, at nearly 30 years, so that we can compare him with the age group 30–39 of the native American male, with a marriage rate of 68.8 per cent., closely approximating the Harvard average.

TABLE I.

MARRIAGE RATE. 30 CLASSES, 4,408 GRADUATES.*

Group 40—49 years of age, approximately.

3,009 College Graduates, 22.5–47 years of age.					Population at large.	
27 Classes from 5 Colleges.	No. of Years out of College.	Number of Classes.	Year of Graduating.	Per Cent. Married.	Per Cent. Married.	Male population of Massachusetts, 40–49 Years of Age.
Brown	25	1	72	88.7%		
Bowdoin	25	2	'75 and '77	86.9		
Yale	25	1	73	82.3		
Bowdoin	25	1	61	82	79.02	Native born.
Princeton	25	1	76	80		Foreign born.
Yale	25	10	'60–'79	78.4		
Harvard 25 years	71.6	9	'72–'80	71.4		
Harvard 20–23	71.1					
545 College Graduates, 10–11 years out of College.						30–39 years.
Harvard	10	1	79	54.2	68.8	Native born.
"	11	1	86	51.9	74.5	Foreign born.
Princeton	10	1	91	75.4		

Group 20—29 years of age, approximately.

848 Graduates 7½ Years out of College, 22.5–30 Years of Age.				Male Population of Massachusetts, 20–29 Years of Age.	
Princeton 7½	1	'95	43%	27.7%	Native born.
Harvard 7½	1	'95	26%	36.2%	Foreign born.

* This table is arranged according to rate of marriage.

Accepting 22.5 as the age of graduating,* graduates of 1895, 7½ years out of college would have attained the age of 30 and must have married between the ages of 22.5 and 30, so that they are comparable to native males of the age group of 20 to 29, with a marriage rate of 27.7 per cent. The Harvard class of '95 shows a somewhat lower rate, 26 per cent., but the Princeton class of the same year a very much higher one—43 per cent. The Princeton class of 1891, ten years only out of college, has 75.4 per cent. of its members married, more than any Harvard class as far back as '72 shows after its twenty-fifth anniversary.

These figures, though small and bearing on only a few of the many colleges, certainly indicate that the male college graduate in this country is not more given to solitary life than the native male of all classes throughout the state and that the supposition of Rubin and Westergaard for Denmark, that the marriage frequency of the professional class is only two thirds that of the average does not hold good for the American alumnus, and probably not for the professional classes of the United States. It shows that a larger per cent. of college graduates marry, and those of some colleges marry in such numbers that it would appear that they marry as early as does the average native male, because the percentage in the earlier years is the same for average males and graduates.

The marriage rate of Harvard graduates alone differs from that recorded for all alumni investigated, from Princeton, Yale, Brown and Bowdoin, so that the alumnus of this institution can not well serve as an exponent of the highly educated part of our population, or even of the average college graduate, differing distinctly from this group and less than that of the native male of the same age throughout Massachusetts with a marriage rate of 79 per cent. (I recall that for purpose of comparison with the 25 year graduates, I have taken the age group 40 to 49 of the native population, which presents the highest marriage rate, 79.02 per cent.)†

* 22.5 years is the average age of graduating for the Princeton classes 1901–02, 22.6 for Yale classes 1882–92, 22.8 for Yale 1892–02; for a crude average 22.5 will answer. For Harvard the age of entering is 19 with a probable 22.9 for graduating, an approximation necessitated by the non-existence of authoritative data.

† My figures are based on a study of 4,408 alumni from leading eastern colleges: 848 graduates 7½ years out of college, 545 10 and 11 years out and 3,015 25 years out, and I have been careful to record rates for all older classes, *i. e.*, graduated more than 25 years ago, as given at the time of the twenty-fifth anniversary, for purposes of comparison on a just basis. This explains some trifling discrepancies which may be observed between my figures and others recently published. To me it seemed the only correct procedure. The Harvard classes '78, '79 and '80 are reported on a 23, 21 and 20 years' basis respectively, making but a slight difference, as may be seen by a study of Princeton '91.

The fecundity of graduate marriages, the total number of children born (gross fertility) is a trifle less than that of the average native marriage, rarely above, as in the Princeton class of '76, with 3.2 children: it is 2.55 for the Yale classes 1860–80, 2.4 for Brown '72, 2.07 for Harvard 1872–80, 2 for Bowdoin 1875 and '77 as compared to 2.7 for the native American family of Massachusetts according to the refined statistics of Kuczynski, which show a greater fecundity for the native population than is proved by my studies in St. Louis and those of Dr. Chadwick in Boston, 2.1 and 1.8 respectively.* Even granted so high a fecundity as 2.7 for the average native family, the *surviving* children under this assumption are only 1.9 to the family; the lower death rate for children of the cultured and well-to-do—10 per cent. in college graduate families against 28.5 per cent. for the lower classes—reverses the relative status when we consider the actual family size; the number of surviving children, the net fertility: this is greater for the graduate family (see Table II.); and it is the surviving children who serve to reproduce the population. 1.9 (1.92 precisely) is the largest possible number for the native population of Massachusetts, as compared to 2.7 for Princeton, 2.28 for Yale, 2.26 for Brown, 1.86 for Harvard 1872–80, 1.88 for Bowdoin.

TABLE II.†

DEATH RATE IN FAMILIES OF PROFESSIONAL AND LABORING CLASSES.

Parentage.	Number of Children to each Married Couple.		Death.		
	All Born.	Surviving.	Number Died.	Death Rate Per Cent.	
3015 College Graduates	*2.34*	*2.1*	**0.24**	**10 %**	United States.
Population of Mass. Native Born.	*2.61*	*1.92*	**0.69**	**28.5**	United States.
Population of Mass. Foreign Born.	*4.53*	*3.01*	**1.52**	**33.4**	United States.
Denmark. Upper Class	*4.52*	*3.31*	**1.21**	**26.7**	
Denmark. Artisan and Laboring Class	*4.95*	*3.14*	**1.81**	**36.6**	
Berlin. Military or Upper Class				**12.84**	Europe.
Berlin. All Children				**24.72**	Europe.

* My own data are obtained direct from the mother and will more correctly represent existing conditions than figures like those of Kuczynski secured by additions for possible omissions to state registration records. I must add that they show, on an average, the number of children borne in 10 years of marriage, which should be very near the total.

† This table does not quite indicate what I wish to show, as the mortality rate compared with that of the graduate family is not the mortality in families of the lower and laboring classes, but in those of the entire population, which includes the educated and professional classes.

Graduate families are, as these figures show, not only not smaller, but they are larger than those of the native-born American population of all classes, and larger than would have been expected from what is known of the relative fecundity of rich and poor in other countries. The relation of the educated and professional classes to the masses, to the laboring or artisan class, however, is the same as that shown for Copenhagen by Rubin and Westergaard, the total number of offspring born being somewhat larger for the family of the artisan; the real family, the number of the surviving, on the contrary, being somewhat larger for the educated, for the reason of the lower death rate in such families.

The rate of child-birth has been decreasing in college families, but it has been decreasing throughout the civilized world, slowly in the old world, with astonishing rapidity in the new, that is, among the native American-born of our population, until it has reached a minimum; the number of children to the native American family of all classes (and in this lies the danger) being less than it is in any other country, France even not excepted, which has long been known to be at the point of stagnation.

These are facts; the figures have all been elaborated and repeatedly presented so that any hypothesis is unnecessary. The American population is not holding its own; it is not reproducing itself, and the highly educated do not stand alone in this.

Important as is the fact of our racial decline, bearing as it does upon our future as a nation, it has not been observed, because of the fair general rate of child-birth, due to the much greater fecundity of the foreign element, which is from 2 to 2½ times that of the native, thus bringing the total birth rate of the state to an equality with that of France,—22.4 per 1,000 living population, or above it.

This is true of six representative states, for which we have fairly reliable statistics; in some, the birth rate is distinctly higher than that of France, as high as 26 and 28 per 1,000, but even in such states, that of the native-born is far below that of France. So in Massachusetts, with a total birth rate for the state of 27.78, practically 28 per 1,000 living population, that of the native-born is only 17, whilst that of the foreigner is over 52 per 1,000.

The net fertility, the total number of children born is 2.1 in France, and for the native population of the above state it is said to be 2.17 for 3,015 graduates from 25 classes 1870–80, in five eastern colleges it is 2.34. But these figures may be ignored, as it is not the total number of children born, but the *surviving* who add to the population, and it is these whom we consider: the *surviving* children of college graduates, 2.7 for Princeton, 2.28 for Yale, 1.86 and 1.88

for Harvard and Bowdoin, respectively, must be compared with the number of surviving children for the native American population of the state of Massachusetts, which is 1.9, less, according to my own observations.

Less than 2 surviving offspring to reproduce the race for all native-American marriages, 2.1 for those of the limited group of college graduates!

This indicates a remarkable change since the days of Benjamin Franklin, who tells us that 'one and all considered each married couple in this country produced 8* children.' Though this is not a conclusion drawn from statistical study, it is yet indicative, and in harmony with my own deduction from genealogical records. Whatever the precise figures be, all observations agree as to the high fecundity of the American colonies, and tell of the great change which has taken place in one short century.

From conditions better than those in any other country, five and more children to the family, such as led to the Malthusian theory of superfecundation and to the fear of over population of the earth's surface, we have passed in hardly one hundred years to our present condition, with a fecundity for the native-born below that of any other country, such that the American race is unable to reproduce itself with a birth rate of 17 per 1,000 population,† hardly 2 children to the family!

These facts I first presented in 1901,‡ with records up to the end

* Let no one discredit this and call it impossible! Though surprising to us with a knowledge of the present, these figures are even exceeded at this day by the French-Canadian with a fecundity of 9.2 children to the family, as I gather from a study of one thousand families found in the records of Quebec life insurance companies: 9.3 for the rural, 9.0 for the urban population, is the fecundity of the child-bearing woman, not the fecundity per marriage, but nearly so, as sterile marriages are rare. The birth rate of the Russian peasantry in the Kaluga district, near Moscow, is 7.2 children to the marriage. Throughout Norway it is 5.8 at the present time, as much as it was in the American colonies at the time of the Declaration of Independence.

† That the native population is dying out, and that at an alarming pace, is evident, not alone from a birth rate much lower than that of France, but also from a comparison with that of Berlin. In France the birth rate was 22.5 per 1,000 living population; that of the native population of Massachusetts is 17 per 1,000; in Berlin, 1891–95, with *10 births for every 100 women of child-bearing age*, the births were one ninth behind the number necessary to keep the population stationary, whilst in Massachusetts the birth rate is *much lower, 6.3 births for 100 adult American born women of child-bearing age.* The result is self-evident.

‡ The subject has been treated in the following papers by the writer: 'The Increasing Sterility of American Women, with Increase of Miscarriage and Divorce, Decrease of Fecundity.' Engelmann, *Jour. of the Amer. Med. Assoc.*, October 5, 1901. 'Decreasing Fecundity Concomitant with the Progress of Obstetrics and Gynecology.' Engelmann, *Philadelphia Med. Jour.*, January 18, 1902. 'Birth and Death Rate as influenced by Obstetric and Gynecic Practice.' Engelmann, *Boston Med. and Surg. Jour.*, May 15, 1902.

of the eighteenth century, when the decline began, and at the same time I published complete statistical data for the end of the nineteenth century, when the lowest level had been reached.

I have shown that a gradual decline had already taken place during the colonial period from 6 and more children in the seventeenth century to 4.5 at the end of the eighteenth; then 2 at the close of the nineteenth; data for the intervening period I had none. It seemed reasonable to conjecture a gradual decline with developing civilization and rapidly increasing luxury of life, but proofs were wanting.

The Yale records fill the gap, and supply the intervening data I had so far persistently but vainly searched for; they distinctly portray the gradual decrease in the rate of child-birth and enable me to complete the table, period by period, which shows the remarkable changes that have taken place in family life in this country. To this the highly educated portion of our population is no exception. The decline is general, not confined to any one element, it is the same for college graduate and laboring class, for all American-born, for highly educated and less highly educated, so that higher education can not be the causative factor.

This table presents a startling record for a young and vigorous community, and it is but natural that we should ask for the cause of this rapid decline in birth rate among all classes of the American-born: where are we to seek the explanation? It can not be in physical inability, though the ravages of venereal disease are leaving their traces more clearly with increasing civilization and centralization, and constantly add to the number of the sterile. (This is 2.5 per cent. among a simple, hard-working people in the interior of Russia (Kaluga), and in Norway, whilst 20 and 25 per cent. of marriages are barren in the civilized and infected communities of the United States and of France.) I find 25 and 30 per cent. of families barren among the married graduates of large and centrally located colleges, as low as 9 per cent. in a Princeton class with high marriage rate and large families, an exceptionally healthy condition when we remember that 20 per cent. of all native marriages in the entire state of Massachusetts are childless.

The cause for this decline in family size can not be sought in the increased age for marriage, as this is delayed for all educated and professional men in this country as in England by nearly three years, from 27.2 to 30 for the male, and for the educated female from 24.3 to

* This steady decrease in the number of offspring in college graduate families is admirably shown by Professor Thorndike in his article on 'Decrease in Size of American Families' (POP. SCIENCE MONTHLY, May, 1903). Unfortunately he does not give the number of surviving children and pictures only graduate families.

TABLE III.

RACE DECLINE. DECREASE IN SIZE OF THE AMERICAN FAMILY.

Period of Observation.	Locality or Group.	No. of Cases.	Number of Children to Each Married Couple.	
			All Born.	Surviving.
Am. Colonies	Benjamin Franklin.		8	
1700–1750	Genealogical Records.	503	6.6	
1750–1800	" "	784	6.1	
"	Am. Colonies (Sadler).		5.2	
"	New York State.		5.2	
1726–1779	Hingham (Town Rec.).	521	4.3	
1727–1784	Salem " "		4.6	
1783	Hingham (Holyoke).		4.6	
1800–1830	Genealogical Records.	213	4.6	
1804–1811	Portsmouth.		4.3	
1810–1842	Yale Grad. Class Rec.	447	4.13	
1842–1860	" " " "	839	3.33	
1861	Bowdoin " "	45	2.62	*2.35*
1860–1879	Yale Grad. " "	1104	2.55	*2.28*
1872	Brown " " "	53	2.45	*2.26*
1876	Princeton Gr. " "	118	3.2	*2.7*
1872–1877	Harvard " " "	888	2.21	*1.97*
1877–1880	" " " "	513	1.87	*1.66*
1885	State of Mass. { native-born.		2.69	*1.92*
	{ foreign-born.		4.5	*3.01*
1870–1880	Boston Labor Class, Chadwick.*	1374	1.9	
1870–1890	St. Louis Labor Class, Engelm.*	804	2.1	
"	St. Louis Higher Class, Engelm.*	114	1.8	
1900	Boston Upper Class, Engelm.*	600	1.8	*1.8*
1885	Female Col. Grad., Wright.*	804	1.3	
1900	Female Col. Grad., Smith.*	343	1.8	*1.6*
	Female Col. Grad., England.	58	1.5	

From table of Prof. E. L. Thorndike excluding families where husband died in first 10 years of married life—for Middlebury and N. Y. Univ., for Wesleyan all married are taken.

All Children Born.

	Middlebury.	Wesleyan.	New York University.
1803–09	5.6		
1810–19	4.8		
1820–29	4.1		
1830–39	3.9	4.5	4.0
1840–49	3.4	3.3	3.2
1850–59	2.9	2.2	2.9
1860–69	2.8	2.6	2.5
1870–74	2.3		
1875–79	1.8		

26.4, but as the number of surviving offspring is not less, this delayed marriage can not be looked upon as a factor in determining the small size of the graduate family. The cause is not to be sought in education, in so far as the male is concerned. The educated female is in a different class; the fecundity of the female college graduate in this country is lower than that of any other native group, and this low birth rate holds good for her English sister as well, the very small size of her family—smaller than that of the American alumna—standing out in striking contrast with the much higher fecundity of the English people, which is nearly double that of the native-born of the United States.

Family shrinkage seems clearly referable to the strenuous, nerve-racking life of the day, to the struggle, not for existence, but for a

* Average 10 years of married life.

luxurious existence, to the ever-increasing desire for the luxuries of life and the morbid craving for social dissipation and advancement. It is due, as plainly expressed and openly advocated by many, to the desire to have no children or only such a number as husband and wife believe in their wisdom suitable and adapted to their ideals of comfort, and to their supposed financial possibilities; the most important factor is the "deliberate and voluntary avoidance, the prevention of child-bearing on the part of a steadily increasing number of married couples,* who not only prefer to have but few children, but who 'know how to obtain their wish' " (Dr. John S. Billings). Professional observation and the plainly expressed ideas of men and women who do not hesitate to make known their views substantiate the above, as does the startling decrease of fecundity and the corresponding increase in sterility in the face of the scientific progress of the day in all that pertains to the physical well-being and health of woman. This decrease of fecundity in the face of advance in obstetrical and gynecological science, which should lead to a healthier condition of the child-bearing organs—a decrease confined to one element of the community, the native American—clearly proves the condition to be one determined by the volition of that element. Families are small among all classes of the native-born, large among all classes of the foreign-born population, showing that the cause of this low fecundity is not universal but it is one confined to the native element only; this limiting of the small family to the native of all classes in itself would prove that education is not that cause, were such proof not made needless by the fact that the family of the educated man is actually larger than that of the native male throughout the state.

Let us no longer beat about the bush and attribute the low fecundity now prevailing to later marriages and higher education. This explanation has been accepted because it is a tradition and universally credited; it is not so in other countries, and it has never been proved to be so for the United States. Theoretically later marriage must, it would seem, lead to the lowering of the birth rate. Facts plainly disprove this, and why should higher education lessen the size of the

* I have used the word *couples* intentionally, though in the original it is *women;* Dr. Billings says that the cause of declining fecundity is in the 'voluntary prevention of child-bearing on the part of a steadily increasing number of married women,' indicating that the *wife* is mainly at fault, whilst in truth *it is the husband* to an equal and *even a greater extent*, according to my observation.

In defense of the American woman it is but right to call attention to this fact and to correct the false impressions which are prevalent. This assertion is substantiated by experience and by the carefully prepared Michigan registration reports.

family as all seem to assume? Because the years of marriage are less? This is a hasty assumption as will appear when we recall that all children are born on an average within 7½ years after marriage, some authorities even say within 5 years. Accepting the longer term of 7½ years, this leaves the alumnus who marries 7 years after graduating in his thirtieth year, at 37½, and his wife, who marries at the latest at 26.4, in her thirty-four year. The end of the average child-bearing period falls accordingly for both the late marrying graduate and his spouse, still in the most vigorous period of life, 37½ for the educated male, 34 for the female, not so late as to interfere in any way with the family prospects. This is true for the college graduate; for the entire highly educated portion of our population I have no data and make no assertions. No figures are available for a group such as this, and this must be noted as the family size of this class has of late been considered. It is too comprehensive a term, and has been somewhat indiscriminately used in recent discussions of race decline; even far-reaching conclusions bearing upon this large group of the highly educated have been based upon data derived from the graduates of a single institution. Not even from those of several institutions if under similar conditions or even if of the same sex are we warranted in judging of the entire highly educated part of our population. The female college graduate must be classed among the highly educated, and the number of children in her family is below that of the native population; it is lower than that of any other group, whilst that of the average male graduate family is higher. Then again the college alumnus can not without further investigation be accepted as a standard, for even the highly educated male, as appears from the facts presented by Professor Dexter in his recent study of 'High Grade Men: in College and Out.' He shows that hardly more than one third, 37 per cent. of the 8,602 supposedly successful and prominent Americans mentioned in 'Who's Who' are college graduates, and only 2.2 per cent. of all now living alumni are included among these 8,000 supposedly higher type and most representative of living Americans. Regardless of this the variation in marriage and birth rate of the different elements of this group of the highly educated make it impossible to consider them jointly.

These facts, together with the limited data on hand, make it impossible as yet to reach conclusions of any kind as to the part taken by the highly educated portion of our population as a class in race reproduction; it is the male college graduate whom we here consider and compare, not with the male of the entire population, but with the native-born American only. I emphasize this as the two groups, the native- and foreign-born of our citizens differ widely as to the part they

play in reproduction of race. If the term highly educated is here used it refers solely to the college graduate.

A high marriage rate and an average of 2.1 surviving children to the graduate family as compared to 1.9 for the native-born male throughout the state tells us plainly that, contrary to all theory and supposition, higher education does not mean diminished reproduction. It is the American nationality that stands for lessened marriage and low birth rate, in striking contrast to the foreign-born of our citizens with families of from 3 to 5 children, 4.5 in Massachusetts with 3 surviving, and this is true for all classes of foreign-born.

Graduates as a group make an exceptionally good showing, and college alumni are to be congratulated upon the standard maintained; the net fecundity is greater, family size is larger than that of the general native population and marriage rate of some groups is higher, so that reproduction is more nearly approximated by the college graduate family. Contrary to European statistics for professional men, who, as already stated, are assumed to have a marriage rate two thirds less than the average male of the population, class reproduction for college graduates is higher than it is for the population at large.

The average marriage rate for 1,614 graduates of the classes 1870–77 from Yale, Princeton, Brown and Bowdoin is 79.4 per cent. and for a corresponding group of Harvard graduates, 1,401 of the classes 1872–80, it is 71.4 per cent., a rate so much lower than that for graduates at the other institutions named that we must differentiate. The average of these 3,015 alumni of both groups is 75.7 per cent.

The marriage rate of Harvard graduates varies so much from that of the alumni of all other institutions so far investigated that the Cambridge graduate can evidently not serve in this respect as an index for family conditions among college men any more than he can be looked upon as representative of that other element of the highly educated portion of our population, the female college graduate with a marriage rate of from 30 per cent. to 50 per cent. or, for still another, the highly educated man who has never received an academic degree and this, as has recently been shown, is a surprisingly large number in this country. The general marriage average of 79.4 per cent. for a group of graduates from four colleges and 71.4 per cent. for Harvard alumni must be compared with 79.02 per cent. for the native male population of the age group 40–49 years, and is greatly to the credit of college men. By reason of this high marriage rate the number of surviving children for 100 graduate members of a group or class, married and unmarried, is larger than it is for the less highly educated and in fact larger than it is for all other elements of our native male population, even where the number of children

to the married couple is the same; to this the Harvard graduate is an exception; with both family size and marriage rate lower than the graduate average and lower than that of the native-born male of Massachusetts (of a comparable age group—40–49 years), reproduction per class is naturally less. A Princeton class, if we may take '76 as an example, more than reproduces itself: it reproduces not alone the married couple, 2.7 surviving children to each, but more than reproduces the entire class, 2.3 to each class member, married and unmarried (2.3-net class reproduction). Brown just reproduces itself with 2.26 living children to the married graduates and precisely 2 to each member of the class.

All classes later than 1870 of other institutions so far considered fail to reproduce themselves, most so Harvard alumni. Yale graduates very nearly reproduce themselves with 2.28 surviving children to the married graduate and a net class reproduction of 1.78 (*i. e.*, for each member of the class). Next comes the single Yale class of '73 with a class reproduction of 1.57 children. The two Bowdoin classes 1875 and '77 are represented by 1.5 and the 9 Harvard classes 1872–80 by 1.3 children for each graduate, married and unmarried (1872–77 by 1.4 and 1878–80 by 1.19 respectively).

A great decrease has indeed taken place in the birth rate of graduate families, but not quite to the same extent as among other groups of the same social grade: the wealthy or leisure class, the well-to-do invariably do less towards reproducing themselves than does the population at large; the college graduate, the highly educated male, does more.

TABLE IV.

REPRODUCTION OF CLASS AND RACE.

Number of Classes.	College.	Year of Graduating.	Number in Class.	Per Cent. Married.	Number of Surviving Children.		
					To Each Married Graduate.	To Each Member of Class Married and Single.	To Class of 200.
1	Princeton ...	'76	118	80.4	2.7	2.3	460
1	Brown	'72	53	88.7	2.26	2.—	400
10	Yale.....	'60–'79	1,105	78.4	2.28	1.79	358
1	Yale.....	'79	118	81.3	2.05	1.66	332
1	Yale.....	'73	113	82.3	1.98	1.57	314
2	Bowdoin.....	'75 and '77	107	86.9	1.88	1.56	312
9	Harvard	'72–'80	1,401	71.4	1.86	1.34	268
25		'70–'80	3,015	75.7	2.1	1.49	350
	Yale, Princeton, Brown and Bowdoin.						
16	Y. P. Br. Bo.	'60–'80	1,614	79.4	2.28	1.81	362
9	Harvard	'72–'80	1,401	71.4	1.86	1.34	268

This table is arranged according to rate of reproduction.

In view of the data here presented the college graduate does more towards reproducing the population than does the native American of other classes—this is true even of Bowdoin alumni but not of those of Harvard with a lower marriage rate.

I am well aware that this statement must cause surprise. It is contrary to all tradition, but in harmony with the conditions known to exist in all countries of the old world where recent statistical study has enabled us to make such comparisons.

Résumé.—The data now available indicate that the highly educated male element does more towards reproducing itself than any other large group of our native population. The marriage rate is the same, and the number of surviving children to the family is greater than it is for the native population at large, so that we can no longer accuse the college graduate or, if I may say, 'the highly educated male portion of our population,' of having an exceptionally small family, and of doing less than other groups towards reproducing the population; nor must we lay the blame for the low fecundity of the native American family on higher education. Shortening the term of college study will effect no change. Wealth, luxury and social ambition are cause of the diminishing size of the family and of race decline. The factors are the same which have been active in earlier civilizations as they are to-day: increasing wealth and the introduction of foreign manners are pointed out as causing in ancient Rome the lessening fertility among the better classes which preceded political disruption. Cause and effect were the same and even the methods employed to thwart the tendencies of nature were the same: "Few children are born in the gilded bed, to the wealthy dame, so many artifices has she, and so many drugs, to render women sterile and destroy life within the womb" (Juvenal Sat. VI., ll. 594).

The assumption of a false social position, the struggle for the attainment of luxury even more than its possession, leads to the limitation of the family, by 'the increased amount of restraint exercised,' as one author delicately expresses it, but to speak without circumlocution, by often ruinous measures for the prevention of conception, and by criminal means for the destruction of the product of such conception if it does accidentally occur. Such, in plain words, are the causes which lead to the small size of the American family of all classes.

DISCUSSION AND CORRESPONDENCE.

MAGAZINE SCIENCE.

To the Editor: In the course of the past year or two I have read quite a number of articles on scientific subjects in different magazines by Carl Snyder. They seem very interesting, and I should like to know whether they are quite reliable.—B. F. L.

[This question, which in one form or another has been asked a number of times, must be answered in the negative. Mr. Snyder appears not to have had a scientific training; his articles are sensational and inaccurate. This somewhat sweeping condemnation is easily justified. Let us consider the last article by Mr. Snyder that has come to our attention—'The Mechanism of the Brain' in *Harper's Monthly* for May. It is a potpourri of truth, half-truth and falsehood concerning chemistry, physics, anatomy, physiology and psychology. Thus we are told:

> Or, supposing that this especial colloid cannot be fixed upon as the seat of the highest powers of man, they might be thrown upon that extraordinary and rather hypothetical ether, of which physicists talk so much and know so little.

Within half a column Mr. Snyder passes easily from the ether to electricity:

> As there is no nerve action without the evident presence of electricity, it seems probable that nerve action, thought, and consciousness, and what in our present ignorance we call electricity, are one and the same

Physicists may not know all that they would like to know about the ether and electricity, but they know enough not to write nonsense about them.

As an example of misstatement of fact the following may be quoted:

> The size of the brains of comparatively few distinguished men is known, and most published figures are worthless. The list given below is authoritative, and speaks for itself. . . . It will be seen that Byron, who was commonly supposed to have a small head, is highest in the list; and whatever may be thought of his poetry, certainly he was a man of rather mediocre intellectual attainments, as poets generally are.

The question of the intellectual attainments of poets may be left to the editor of *Harper's Monthly;* we are able to state definitely that the weight of Byron's brain is unknown, as is also true in the case of Turgenieff, whose brain is given as the second largest on Mr. Snyder's 'authoritative' list. In the same paragraph Mr. Snyder says:

> Directions for measuring the size of your own brain, if you are interested, will be found in any good encyclopædia, or would doubtless be supplied by the distinguished Professor Wilder of Cornell.

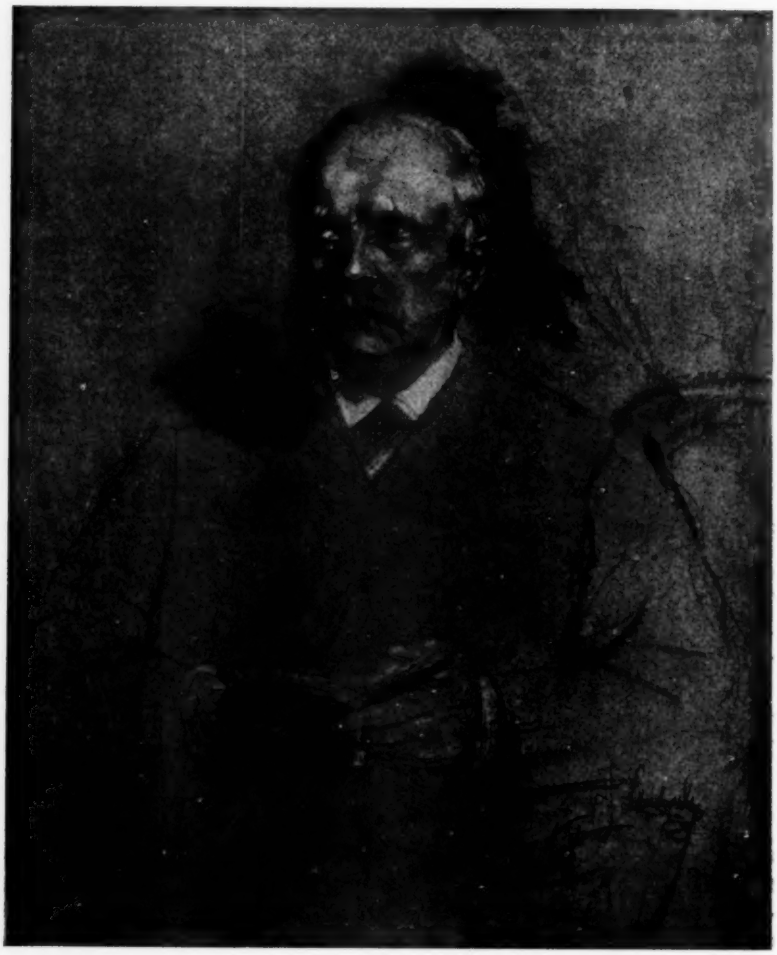
Apart from such indications as are given by the size of the hat, the only feasible directions would be for the interested person to commit suicide, bequeathing his brain to Professor Wilder's collection.

It may seem unkind thus to criticize Mr. Snyder's articles, but it is unfair to the public for magazines, such as *Harper's, Scribner's, The Century* and *McClure's,* not to separate their science from their fiction.—EDITOR.]

SCIENTIFIC LITERATURE.

HERMANN VON HELMHOLTZ.

HERMANN VON HELMHOLTZ, one of the great names in the history of science, is the subject of a sympathetic and dignified biography prepared by Dr. Leo Koenigsberger and published in three volumes by Vieweg. The interests of von Helmholtz were so far-reaching, his activities so multifarious and his intellect so profound that the preparation of an adequate memoir was a task of unusual difficulty. It is fortunate that it has been so adequately performed. Hermann Ludwig



HERMANN VON HELMHOLTZ.
From a drawing by Lenbach (1894).

Ferdinand von Helmholtz was the son of a gymnasium teacher, his mother, Caroline Penne, being a descendant of William Penn. He was born at Potsdam on August 31, 1821, and died in Berlin on September 8, 1894. After a childhood of ill health, he studied medicine and was for four years a military surgeon; for a year he was teacher in the Berlin Academy of Fine Arts, and afterwards professor of physiology at Königsberg from 1849 to 1855. He was professor at Bonn for three years and was then professor of physiology at Heidelberg from 1858 to 1871, when he was transferred to Berlin as professor of physics. In 1888 he was made president of the Reichsanstalt, organized under his direction. All possible academic and imperial honors were of course conferred on him.

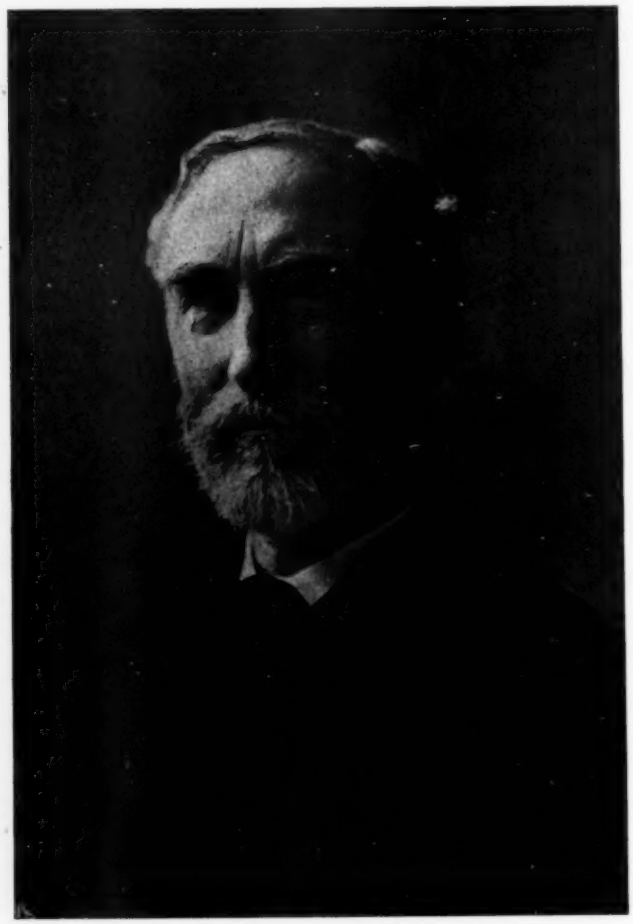
Helmholtz married Olga von Velten in 1849. She died after ten years, and in 1861 he married Anna von Muhl, who died in 1899. One of his sons died in 1889, the other in 1901. His surviving daughter is the wife of Wilhelm von Siemans. Helmholtz traveled more than is the usual habit of the German professor. His visit to America in 1893 will be remembered by many. He seems to have had misgivings in regard to a civilization which has electric lights, while the elements of the art of cookery are 'äusserst Stümperhaft,' and bandits and reporters go at large.

A list of Helmholtz's contributions to science would fill many pages. The essay on the conservation of energy was printed in 1847. Researches of great range and importance, including the invention of the ophthalmoscope, led to his two epoch-making books on physiological psychology—'Tonempfindungen' (1862) and 'Physiologische Optik' (1867). Helmholtz always continued his work in physiological psychology, but his transfer from a chair of physiology to one of physics represented a change in his main interests. His great contributions to mathematical physics, especially electrodynamics, are of almost unparalleled importance.

THE PROGRESS OF SCIENCE.

JOSIAH WILLARD GIBBS.

IT is well known that the past quarter of a century has been one of extraordinary advances in the sciences of heat, light, electricity and magnetism. It is less well known, however, that this period has been one of extraordinary losses by death of the eminent mathematical physicists who have contributed to those advances. Maxwell, Kirchhoff, Hertz, Helmholtz, Fitzgerald, Rowland, Stokes, and now Gibbs, have all fallen since 1879. Only two of these leaders, Helmholtz and Stokes, passed the proverbial three score and ten years; Kirchhoff and Gibbs attained only a little more than sixty years; while the others, as if to



J. WILLARD GIBBS.

indicate that it is the pace of hard thinking that kills, all fell at the age of fifty or less.

Josiah Willard Gibbs was born at New Haven, Connecticut, February 11, 1839, and he died at the same place April 28, 1903. He was the son of Josiah Willard Gibbs, professor of sacred literature in Yale College from 1822 to 1861, and Mary Anna (Van Cleve) Gibbs. His preliminary academic studies were pursued at the Hopkins Grammar School, New Haven, and he entered Yale College, at the early age of fifteen years, in 1854. As an undergraduate he easily won distinction, and he took prizes for meritorious work in Latin and in mathematics.

After graduation from Yale College, in 1858, he spent five years there as a student of the mathematico-physical sciences especially. From 1863 to 1866 he served as a tutor at Yale. The next three years he spent in Europe, studying at the universities of Paris, Berlin and Heidelberg. In 1871 he was elected to the professorship of mathematical physics at Yale, and he held this chair up to the time of his death.

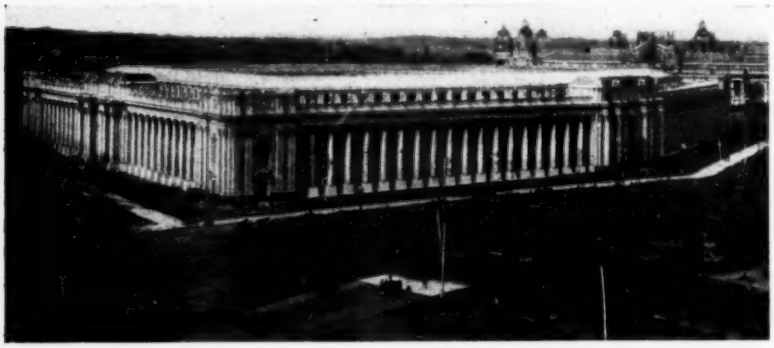
Early in his scientific career Professor Gibbs appears to have concentrated attention on the field of thermodynamics, and during the decade following his appointment to a professorship he produced a series of papers which placed him in the front rank of workers in this field. Indeed, the most important of these papers, 'On the Equilibrium of Heterogeneous Substances,' is now regarded as marking an epoch in the history of thermodynamics and as furnishing the foundation for the new science of physical chemistry. The comprehensive knowledge of mechanical philosophy which made him a master in thermodynamics, made him also an authority in electromagnetic science, and during the decade from 1880 to 1890 he published several noteworthy papers on the electromagnetic theory of light and kindred topics. He was likewise a profound student of pure mathematics. His vice-presidential address, 'On Multiple Algebra,' read before the section of astronomy and mathematics of the American Association for the Advancement of Science in 1886, is an original contribution of great merit in a domain already well worked by Möbius, Hamilton, Grassmann, Peirce, Tait and others. His more recent contributions to science are found in two volumes of the Yale Bicentenial Publications, namely, 'Vector Analysis,' edited by a pupil, Dr. E. B. Wilson, and 'Elementary Principles of Statistical Mechanics.' The unpretentious title of the latter work, though strikingly characteristic of the author, is too modest; for it appears destined to take rank among the small number of fundamental contributions to the science of mechanics.

Professor Gibbs was the recipient of many honors from scientific societies at home and abroad. He knew well how to economize his time, however; and although one of the most genial and kindly of men, he mingled sparingly with the world, and was thus, alas! too little known and appreciated, especially by the younger generation of his fellow-countrymen interested in science.

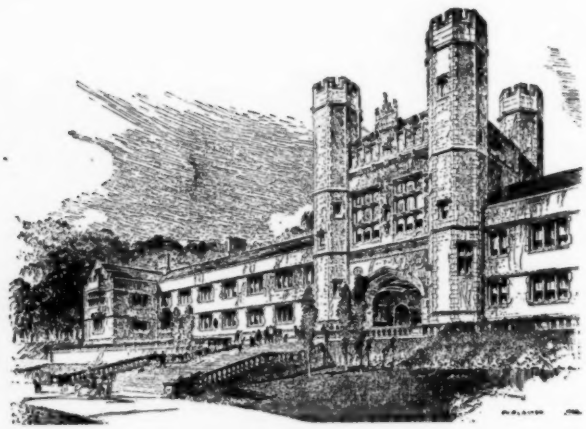
THE SCIENTIFIC PROGRAM OF THE LOUISIANA PURCHASE EXPOSITION.

THE dedication of the Louisiana Purchase Exposition on April 30 demonstrated to a hundred thousand visitors that the preparations are unusually far forward. Many of the buildings are practically ready, and the fencing, grading, road-making and the like of the 1,200 acres are well advanced. Indeed, the exposition bids fair to be bigger and more successful than might have been anticipated. Thanks to hitting upon the psychological moment in international relations and of domestic liberality, money is being spent by the tens of millions,

and a world somewhat weary of world fairs is arousing itself to an active interest in the St. Louis Exposition. Of most immediate scientific concern is the Congress of Arts and Sciences, described by Professor Hugo Münsterberg, of Harvard University, in the *Atlantic Monthly* for May.



EDUCATIONAL BUILDING, LOUISIANA PURCHASE EXPOSITION.



UNIVERSITY HALL, WASHINGTON UNIVERSITY, EXECUTIVE BUILDING OF THE LOUISIANA PURCHASE EXPOSITION.

Professor Münsterberg tells us that he proposed to substitute for the congeries of international congresses which have formed a part of recent world fairs a single congress demonstrating the unity of human knowledge, and that his plan has been adopted in all its details. There will doubtless be some protest against the scheme from men of science, as it is difficult to draw the line between demonstrating the unity of knowledge and illustrating the tenets of Professor Münsterberg's system of philosophy. The catalogue of Harvard University or the names of our national scientific societies would give a more objective classification of the sciences.

Professor Münsterberg divides the sciences into seven groups, of which four are theoretical and three practical. The theoretical sciences are normative (philosophy and mathematics), historical (which do not deal with the

description and explanation of phenomena), physical and mental. The practical sciences are utilitarian, regulative and cultural. These seven divisions are subdivided into twenty-five departments and one hundred and thirty sections. The congress is to open on Monday, September 19, when the three members of the organizing committee will make introductory addresses—Professor Newcomb on scientific work, Professor Münsterberg on the unity of theoretical knowledge and Professor Small on the unity of practical knowledge. In the afternoon there are to be addresses in each of the seven divisions on its fundamental conceptions. On the next day there will be two addresses in each of the twenty-five departments, one on its development during the last hundred years, the other on its methods. On the following four days the seventy-one theoretical and the fifty-nine practical sections will each be addressed by two speakers, one treating the relation of the section to other sciences and the other the problems of to-day. The addresses before the divisions and departments are to be made by Americans, and at least one of those before each of the one hundred and thirty sections by foreigners. The authorities of the exposition have made a liberal appropriation—$200,000 it is said—toward the expenses of the congress. The speakers will be paid, and their addresses will be published.

CONGRESSES OF PHYSICIANS.

THE Fourteenth International Congress of Medicine met at Madrid during the last week of April; the American Medical Association held its fifty-fourth annual meeting at New Orleans in the first week of May, and the Congress of Physicians and Surgeons held its sixth triennial session at Washington during the following week. The multiplicity of sections, societies, addresses and papers is bewildering and beyond the possibility of brief description.

At Madrid there were some 5,000 delegates, those from foreign nations being proportioned as follows: Germany and Austria, 1,000; France, 825; Great Britain, 235; Russia, 290; Italy, 335; other European countries, 327; United States, 193; South America, 136. The prize for original research, established by the city of Moscow, in honor of the meeting of the congress in that city in 1897, was awarded to Professor Metchnikoff, and that of Paris to Professor Grassi. The next congress will be at Lisbon in 1906. No discoveries of an epoch-making character were presented to the congress, though the programs contained the titles of many papers of importance.

The meeting of the American Medical Association was attended by about 2,000 members. Dr. Frank Billings in his presidential address reviewed the present condition of medical education in the United States. There are in the country 156 medical schools which last year graduated 5,000 physicians. To maintain the present ratio of one physician to 600 of the population, which in the cities, at least, is rather an oversupply, only 3,000 recruits are needed annually. Dr. Billings held that the overcrowding of the medical profession must be controlled by higher standards of education. The American Medical Association has recently organized a house of delegates for the discussion of the interests of the medical profession, and this year a code of ethics was adopted. According to the reports presented, the association is in a flourishing condition. Its membership is over 12,000, having nearly doubled within five years. In this period its funds have increased fourfold, the net increase last year having been $40,000. The prosperity of the association is largely due to its weekly journal, which has a circulation of over 25,000.

The Congress of American Physicians and Surgeons, which meets once

in three years at Washington, is an affiliation of national medical societies devoted chiefly to different departments, but including the Association of American Physicians, which is a small and select body of practitioners. These societies, sixteen in number, had special programs, holding their sessions in the mornings, while the congress met as a whole in the afternoons and evenings. The president, Dr. W. W. Keen, of Philadelphia, chose as the subject of his address 'The Duties and Responsibilities of Trustees of Medical Institutions.' The subjects for special discussion were 'The Pancreas and Pancreatic Diseases' and 'The Medical and Surgical Aspects of the Diseases of the Gall-bladder and Bile Ducts.'

SCIENTIFIC ITEMS.

PAUL BELLONI DU CHAILLU, the explorer and author, died at St. Petersburg on April 29. He was born in New Orleans in 1838, and in 1855 he went from New York to the west coast of Africa, where he made the well-known expedition described in his 'Explorations and Adventures in Equatorial Africa.'

AT the recent meeting of the National Academy of Sciences new members were elected as follows: T. C. Chamberlin, professor of geology, University of Chicago; William James, professor of philosophy, Harvard University; E. L. Mark, professor of anatomy, Harvard University; Arthur G. Webster, professor of physics, Clark University; Horace L. Wells, professor of analytical chemistry and metallurgy, Yale University.

THE board of regents of the University of Wisconsin on April 21 elected Dr. Charles R. Van Hise, professor of geology, to the presidency of that institution.—The Walker Grand Prize, which is bestowed once in five years by the Boston Society of Natural History, has just been awarded to J. A. Allen of the American Museum of Natural History 'for his able and long continued contributions to American ornithology and mammalogy.—Professor Simon Newcomb, of Washington, has been appointed a delegate from the National Academy of Sciences to the International Association of Academies, which meets in London this coming June. Mr. S. F. Emmons and Mr. Geo. F. Becker, of Washington, and Professor C. R. Van Hise, of Madison, Wis., have been appointed delegates to the International Geological Congress, which meets in Vienna in August of this year.

MR. ANDREW CARNEGIE has given $1,000,000 for a building for the engineering societies. It is to be situated in New York City, and will provide an auditorium, a library and headquarters for five engineering societies, namely, the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Society of Electrical Engineers, the American Institute of Mining Engineers and the Engineers' Club. Mr. Carnegie has also given $1,500,000 for the erection of a court house and library for the permanent court of arbitration at The Hague and $600,000 to the endowment fund of the Tuskegee Normal and Industrial Institute.